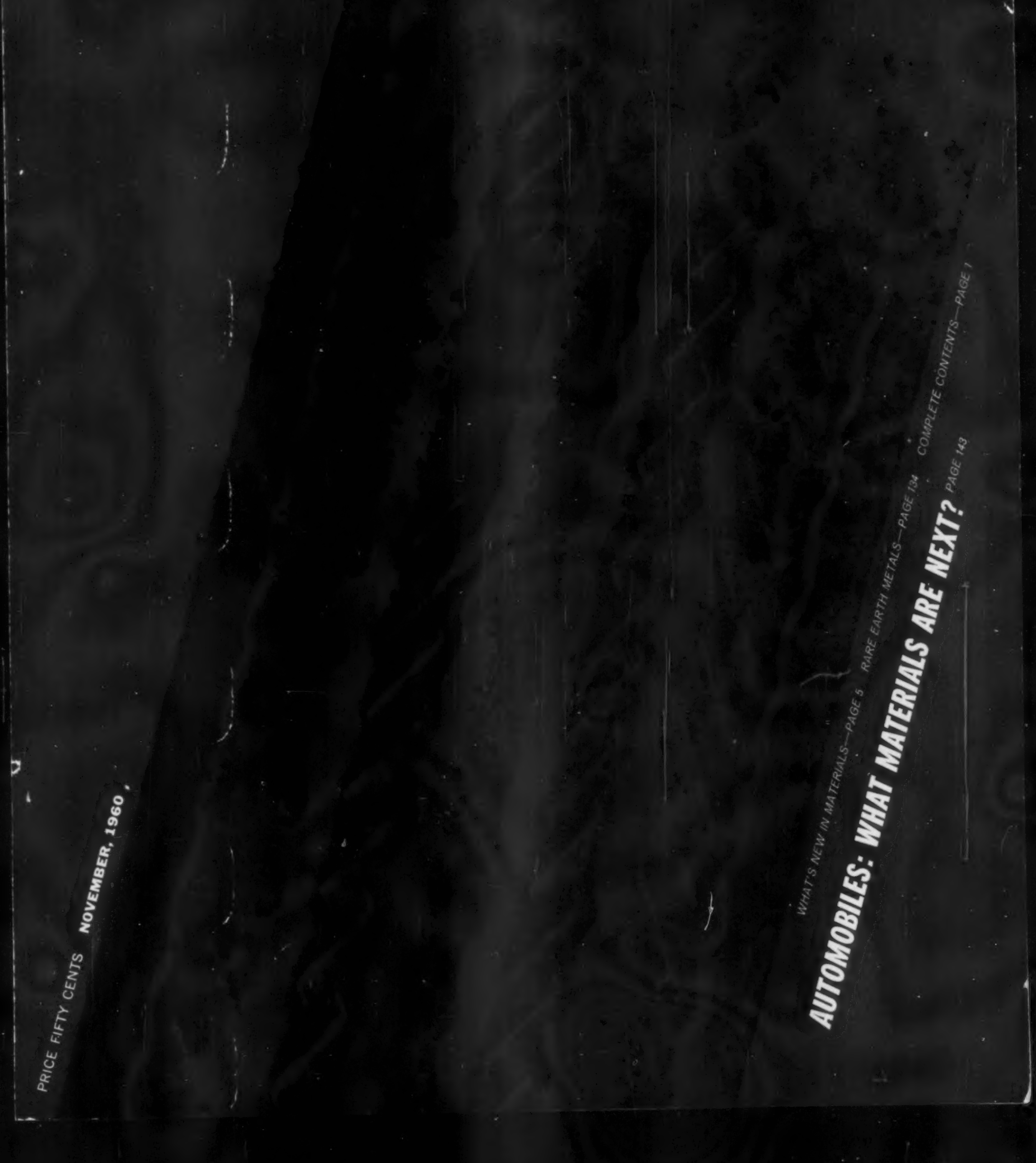
Materials in Design Engineering



PRICE FIFTY CENTS NOVEMBER, 1960

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SEMICONDUCTOR BASES

These Anaconda coppers help you achieve economical volume production of essential electronic components.

As the use of semiconductor devices soars, production methods must be geared to economical volume production, and the selection of metal for the bases becomes critical. Electrolytic Tough Pitch (ETP) Copper has the high electrical and thermal conductivity required, but the severe heat cycling encountered in degassing and brazing the devices during manufacture limits its use. The copper alloy must be deoxidized or oxygen-free to resist hydrogen embrittlement. For secondary operations, it must also have good machinability. And where high torque is used to tighten the base to the heat sink, it must in addition have relatively high strength.

COPPER METALS. Various combinations of the desired properties are found in these Anaconda alloys: DLP Copper-104 (deoxidized low phosphorous), OFHC* Copper-120 (oxygen-free high-conductivity), Tellurium Copper-127, Chromium Copper-999, and Amzirc* (Zirconium Copper)-134.

FABRICATING METHODS. Anaconda specialists can help you select the right alloy and form of metal—and the manufacturing method best suited to meet your design and fabrication problems. Depending on the size and design of the base, the production runs involved, parts may be produced in a variety of ways. Cold heading may be most economical for some, others might be die-pressed forgings, screw machine or punch-press parts. And for many of the smaller parts, multiple-plunger-press fabrication could offer the greatest economies. These specialists can also help you utilize such cost-cutting techniques as roll threading of studs, and advise you on welding and brazing procedures.

Whatever your problem, Anaconda offers specialized technical help—yours for the asking. See your Anaconda representative or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

*Trade-mark of American Metal Climax, Inc.

ANACONDA®

COPPER PRODUCTS FOR THE ELECTRICAL INDUSTRY

Anaconda American Brass Company

For more information, turn to Reader Service card, circle No. 333

NOVEMBER, 1960 | VOL. 52, NO. 5

Materials in Design Engineering

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

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What's New in Materials

Engineering & Design

CONTINUED ON PAGE 3 →

CONTINUED FROM PAGE 1

NEXT MONTH

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Slip Casting: A Good Way to Shape Difficult Parts
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New Synthetic Fiber Papers for Electrical Uses
Sparking Characteristics of Metals
Corrosion Ratings of Copper Alloys
Silicon Carbide for 900 F Transistors
Nickel-Free High Temperature Alloy

Why metals corrode...and how you can prevent it

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide. Six forms of corrosion which can attack the equipment you design are:

1. General tarnishing or rusting with occasional perforations in highly affected areas.

2. Highly localized attack by pitting.

3. Cracking induced by a combination of stress and corrosion.

4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.

5. Corrosion of one of an alloy's constituents leaving a weak residue.

6. Corrosion near the junction of two different metals.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

The electrolyte in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

The plates of the battery correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

Briefly then, for corrosion to occur, there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

When you plan against galvanic corrosion it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

GALVANIC SERIES TABLE

Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron, Cast Iron
•
Chromium-iron (active)
•
Ni-Resist
•
18-8 Stainless (active)
18-8-3 Stainless (active)
•
Lead-tin solders
Lead, Tin
•
Nickel (active)
Inconel* (active)
•
Brasses, Copper, Bronzes
Copper-nickel alloys, Monel*
•
Silver solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
18-8 Stainless (passive)
18-8-3 Stainless (passive)
•
Silver
•
Graphite, Gold, Platinum

HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

When you plan against local action, remember that the corrosion process is galvanic: Electrons move from one point in the metal to another. One of the easiest ways to prevent local action is to use a metal with little or no impurity. When alloys are involved, make sure the constituents are closely listed in the galvanic series table. Local action may also be stopped by the use of protective coatings, which shield the metal from the corrosive media. Environment must also be considered, for its nature may be an important factor in either promoting or restricting corrosion.

TECHNICAL ASSISTANCE

As you can see, many factors are involved in both local and galvanic action. That's why it's best to bring your metal problem to Inco's Corrosion Engineering Service. Available data will be furnished wherever possible . . . tests will be made where needed. Inco's Corrosion Engineering Service will be glad to apply principles of corrosion control to your specific problem.

LITERATURE

The publications listed below will provide more detailed information on how you can combat corrosion by using nickel-containing metals.

Publication Number	Name
A232	Corrosion Problems in Nuclear Reactor Power Stations
A59	Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels
A62	A Theory of the Mechanism of Rusting of Low-Alloy Steel in the Atmosphere
A137	Corrosion by Some Organic Acids and Related Compounds
A144	Some Observations of the Potentials of Stainless Steels in Flowing Sea Water

A complete list of the 187 Inco publications and technical bulletins on nickel-containing metals can be obtained by writing for "List A", to:

*Registered trademark

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N.Y.

For more information, turn to Reader Service card, circle No. 398

What's new IN MATERIALS

...AT A GLANCE

A new leather-like material now under development is causing considerable stir in the shoe and accessories industries. Described as a "breathable polymeric material that has no resemblance to conventional plastics or nonwoven fabrics," the material is said to look like leather, be light weight, and resist abrasion better than leather. It can be waxed or polished, and can be produced with a variety of surfaces, including suede. Unverified reports indicate that the commercial price might be substantially lower than that of leather. DuPont, developer of the material, says commercial production of the material before early 1963 is unlikely.

Two nickel-base alloys for thermocouples can be used at temperatures up to 2300 F. The new alloys are said to provide a type "K" thermocouple in which each leg has an adherent black oxide surface with high emissivity for rapid temperature response.

Source: Wilbur B. Driver Co., 1875 McCarter Hwy., Newark 4, N. J.

High tensile strength glass fibers are reportedly under evaluation. Expected to be in pilot plant production by the end of the year, the fibrous glass is said to provide average filament tensile strengths of 380,000 psi, compared to 205,000-220,000 psi for presently available glass fibers. The material is apparently conventional E glass whose surface is protected by treatment at the glass bushing. First use will probably be in filament winding of reinforced plastics.

Source: Owens-Corning Fiberglas, Inc., 717 5th Ave., New York City.

Close tolerance alloy steel castings are said to result from a new refractory mold casting process, details of which have not been revealed. Castings made by the process can be maintained at tolerances of from ± 0.005 in. per in. on small dimensions to ± 0.002 in. per in. on larger dimensions.

Source: U. S. Magnet & Alloy Corp., Steel Casting Div., 266 Glenwood Ave., Bloomfield, N. J.

Excellent electrical properties and good heat resistance are the claims made for a new synthetic mica paper now in pilot plant production. The electrical insulation has a melting point of 2500 F and can be used at temperatures up to 1800 F. It has a dielectric constant of 3 to 4, a dissipation factor of 0.0005 to 0.0020, and a dielectric strength of 600 to 1000 v per mil.

Source: Synthetic Mica Co., Div. of Mycalex Corp. of America, Clifton, N. J.

Heat resistant optical materials that retain infrared transmission properties at temperatures up to 1800 F have been developed. The developer says the materials are "semi-transparent polycrystalline compounds" that are formed into various shapes by special hot pressing techniques. Composition has not been disclosed.

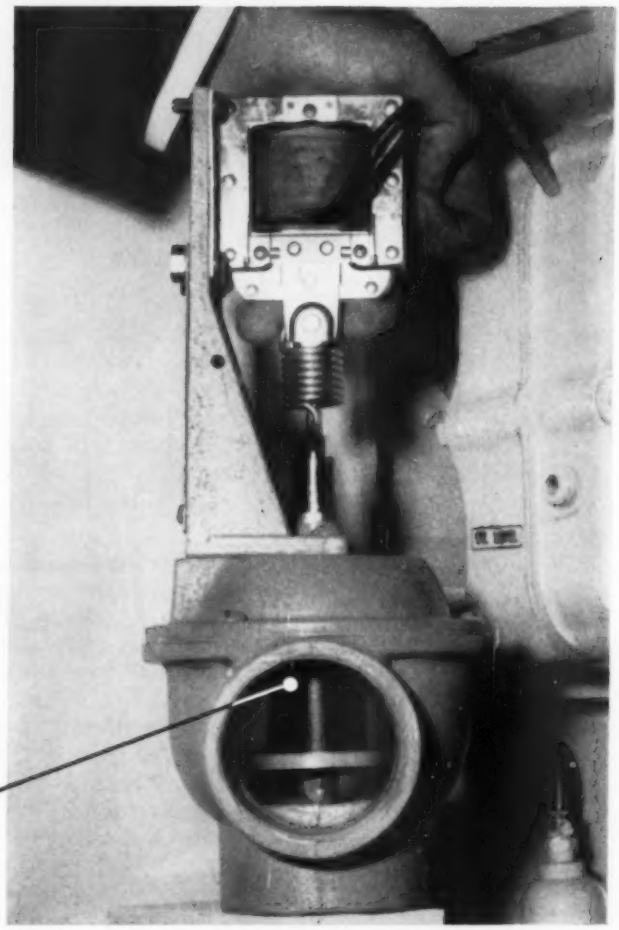
Source: Eastman Kodak Co., Apparatus and Optical Div., 400 Plymouth Ave., Rochester 4, N. Y.

Printed and etched rhodium circuits that are corrosion resistant and easy to solder are possible with a new immersion-type rhodium plating solution. The solu-

Another new development using

B.F.Goodrich Chemical *raw materials*

Willard drain valves, using a diaphragm molded of Hycar by Immel Engineering, Dallas, are used in commercial washing machines manufactured by Cook Machinery, Inc., also of Dallas. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.



Detergents tough on rubber parts as well as dirt

...till Hycar solved the problem

The drain valve for these commercial washing machines is controlled by a solenoid through a rubber diaphragm. Chemicals commonly encountered in soaps and detergents created a problem—till these diaphragms were made of Hycar nitrile rubber.

Hycar is a tough rubber—unaffected by hot water, excessive alkalinity or chemicals. It resists oils, greases, and other hydrocarbons, retaining its resilience and flexibility over a wide temperature range.

Next time you have a rubber problem to solve, it may pay you to know about the unique advantages Hycar brings. For more information, write Dept. FN-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar

Rubber and Latex

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

For more information, turn to Reader Service card, circle No. 383

tion is said to deposit a uniform, extremely thin, pore-free coating on copper and nickel. Tests show that a rhodium plate over copper resists 50% nitric acid solution in 30-min exposure.
Source: Technic, Inc., P. O. Box 965, Providence, R. I.

A galvanized sheet material with improved weldability is designed especially for use in automobiles and trucks. The developer says twice as many spot welds can be made on the new sheet compared to conventional galvanized sheet. One side of the sheet has a zinc-coated surface that provides good corrosion resistance for the interior surfaces of such parts as rocker panels and box sills. The other side of the sheet has a smooth, spangle-free surface that provides a good base for high luster paints.
Source: Armco Steel Corp., Middletown, Ohio.

Tarnish-free silver is promised with the development of a new silicone coating that is said to stick to silver with unusual tenacity. According to the developer, silver treated with the silicone material can be washed repeatedly without fear of removing the finish. Moreover, the silicone coating is said to effectively resist stains from coffee, vinegar, and other foodstuffs.
Source: Union Carbide Corp., Silicones Div., 270 Park Ave., New York 17.

A new type of lead-base solder is recommended for use in soldered joints that operate under load at temperatures up to 400 F. The material is free of boron and iron, making it suitable for transistor work.
Source: Accurate Specialties Co., Inc., 340 Hudson St., Hackensack, N. J.

A newly developed air hardening tool steel is said to be tougher and to have 40% better machinability than oil hardening grades used for the same applications. A big advantage of the new steel is its low hardening temperature (not revealed), permitting it to be heat treated in conventional furnaces. Most air hardening grades have to be heat treated at 1750 F or higher.
Source: Crucible Steel Co. of America, P. O. Box 2518, Pittsburgh 22.

Longer service life for heavy industrial equipment is promised with the development of a new carriage bolt that is said to be twice as strong as carriage bolts now on the market: it has a tensile strength of 130,000 psi compared to 55,000 psi for ordinary carriage bolts. The developer gives three reasons for the bolt's long service life: 1) it is made of high carbon steel; 2) it is triple heat treated to give maximum strength; and 3) it is stress relieved to eliminate head popping and shearing.
Source: Premier Industrial Corp., 4415 Euclid Ave., Cleveland 3, Ohio.

Extremely flat stainless steel strip is being turned out by a new production setup in which two abrasive belt grinders running in tandem grind the strip in a flood of oil. Thickness variations across the width of the strip are said to be less than 0.0005 in. The machines can handle strip up to 28 in. wide and up to 0.240 in. thick. Strip is ground in one pass, compared to three passes required in previous methods according to the producer.
Sources: Behr-Manning Co., Troy, N. Y. and Wallingford Steel Co., 80 Valley St., Wallingford, Conn.

Turn to page 9 for more "What's New in Materials"

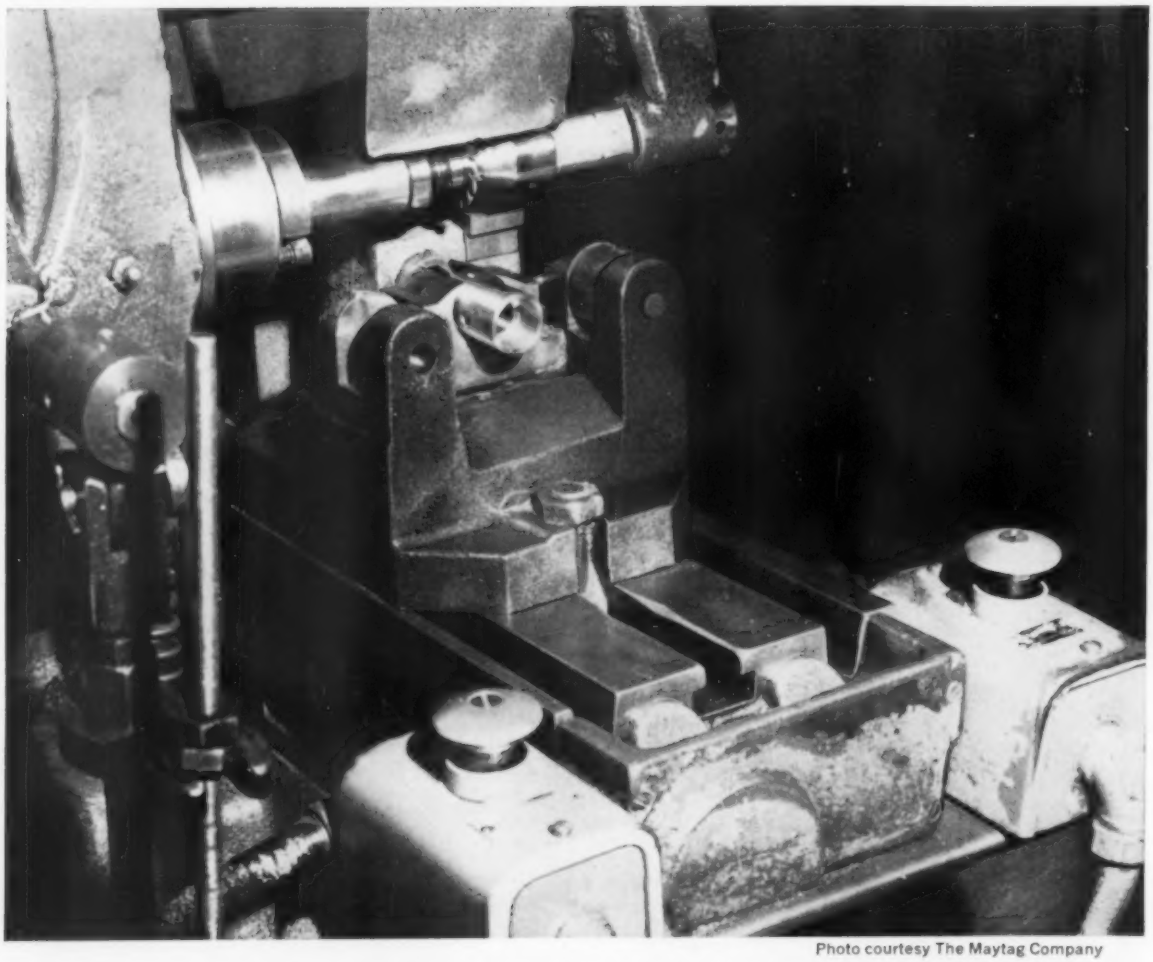


Photo courtesy The Maytag Company

Aristoloy Leaded 8620 cuts tool changes 50% on wringer drive sleeve for Maytag

Has working time been reduced? Yes.

In what way? The use of Aristoloy Leaded* has increased tool life and reduced downtime for tool changes.

Has machining been improved? Yes.

What inherent quality in the steel is responsible for improved machining? A more uniform, satisfactory microstructure provides better machining characteristics.

What operation is performed? Automatic screw machines bore, counterbore and cut off. Secondary operations include milling, drilling, internal and external grinding after carburizing.

For complete information about Aristoloy blooms, slabs, billets and bars, in carbon, alloy, stainless and leaded, call the Copperweld representative in your nearest large city—or write for NEW PRODUCTS & FACILITIES CATALOG.

*Inland Ledloy License

ARISTOLOY STEELS

DIVISION OF
COPPERWELD STEEL COMPANY

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For more information, turn to Reader Service card, circle No. 356

Two New Series of Steels:

- ***Three weldable, high strength grades***
- ***Two weldable, abrasion resistant grades***

Available in a full mill range of sheet and plate sizes, the two series should find wide use in heavy industry.

■ Two new series of steels were recently announced by Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa. Available in both sheet and plate, the weldable, high strength series has been designated Jalloy-S; the abrasion resistant series, Jalloy-AR. Nominal composition of the steels is given in Table 1 and size ranges of sheet and plate in Table 2.

Use of Jalloy-S high strength grades 90, 100 or 110 is expected to permit builders of advanced and heavy-duty defense and industrial equipment to increase the strength of their product and save time and fabrication expense. Areas in which the steels can be applied are: missiles, ordnance, off-the-road construction machinery, hoists, cranes, etc.

Abrasion resistant Jalloy-AR steels 360 and 400, which combine high yield strength with abrasion resistance, should find use as equipment components in the mining, transportation and construction industries.

Jalloy-S

Mechanical properties—Mechanical properties are developed by heat treatment. Mill heat treatment consists of austenitizing at 1600 to 1650 F followed by water quenching while held in a platen press. The press prevents distortion and maintains flatness of the sheets and plates. The steel is tempered at 1150 to 1200 F. Nil-ductility transition temperature is below −75 F.

Typical mechanical properties for the three grades available are shown in Table 3. Although each grade is sold to the minimum yield strength indicated by the grade designation, guaranteed mechanical properties can be negotiated.

Fabricability — High yield strength of the Jalloy-S grades permits reduction in section size. It is recommended that bends be made at right angles to the direction of rolling. Bend radius should be at least twice the metal thickness. For bends parallel to the rolling direction, flange quality is recommended.

Weldability — Low hydrogen electrodes should be specified to avoid underbead cracking. Preheating is not normally required. Recommended electrodes include: AWS Specs E100XX, E110XX and E120XX.

Jalloy-AR

Mechanical properties—Mechanical properties are developed by a heat treatment similar to that used for the Jalloy-S grades. Tempering temperature, however, is reduced to 700 to 1000 F. Transition temperature is −100 F.

Hardness of Jalloy-AR-360 ranges between 340 to 380 Bhn; Jalloy-AR-400 has a minimum hardness of 400 Bhn.

Typical mechanical properties —not to be used as specification minimums—are shown in Table 3.

Fabricability—The precautions noted for the Jalloy-S grades also apply to the Jalloy-AR steels. Principal difference: for sheet and plate 0.079 to 0.50 in. thick, increase minimum bend radius from twice metal thickness to four times the thickness.

Weldability—Recommendations for Jalloy-S steels should be followed.

TABLE 1—COMPOSITION OF THE TWO NEW JALLOY SERIES (%)

Series→	S	AR
C	0.10-0.20	0.25-0.31
Mn	1.0-1.5	1.35-1.65
P, max	0.04	0.04
S, max	0.04	0.04
Si	0.15-0.30	0.15-0.30
Mo	0.20-0.30	0.10-0.20
Cu, min	—	0.20

TABLE 2—AVAILABLE SIZES OF HEAT TREATED STEELS (In.)

Series→	S	AR
SHEET		
Thickness	0.075-0.2299	0.075-0.2299
Width	72	72
Length	240	240
PLATE		
Thickness	0.1875-1.0	0.1875-2.0
Width	72	72
Length	240	360

TABLE 3—TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

Type→	Weldable, High Strength Series			Abrasion Resistant Series	
	S-90	S-100	S-110	AR-360	AR-400
Ult Str, 1000 psi	100	115	122	155	180
Yld Str, 1000 psi	92.7	107	114.4	140	165
Elong (in 2 in.), %	20	18.5	17	15	14
Hardness, Bhn	241	255	269	340-380*	400*

*Guaranteed minimum.

For more information on Jalloy-S, circle No. 600; on Jalloy-AR, No. 601

Nickel-Aluminum Coatings Protect Metals up to 1830 F

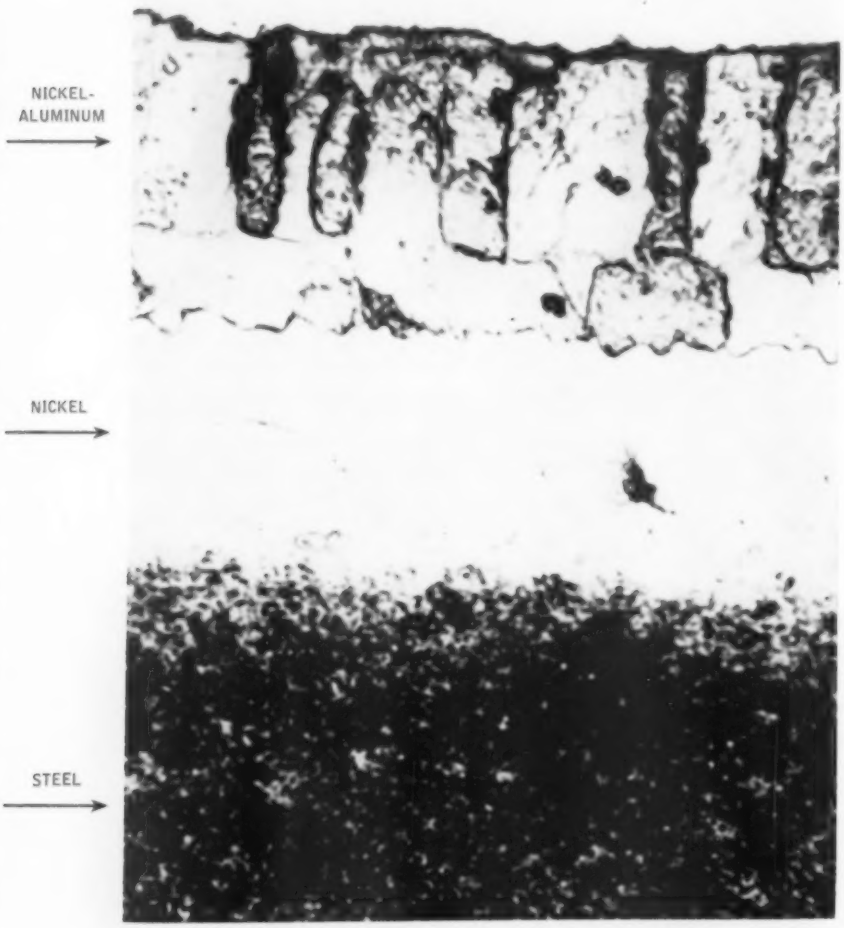
■ In a program sponsored by the Wright Air Development Center, the National Bureau of Standards has developed a method for producing nickel-aluminum coatings that can protect metals up to 1830 F. The coatings have proved effective on steel, nickel and molybdenum, and will probably be applicable to other metals. Because of their high oxidation resistance the coatings are expected to be useful for many aerospace uses.

How they are applied

Cast nickel-aluminum alloys are noted for their good atmospheric corrosion resistance and retention of hardness at elevated temperatures. To date, their brittleness has prevented them from being fabricated into intricate shapes. However, NBS researchers have found that using the alloys as a coating rather than a base metal, i.e., electroplating them on more ductile metals, produces an effective corrosion resistant material.

Two methods have been developed for depositing the nickel-aluminum coatings. In the most satisfactory method nickel is deposited from a Watts-type bath. Aluminum is then deposited on the nickel layer at a current density of 19 to 139 amp per sq ft. The aluminum is deposited from a fused salt solution containing a mixture of potassium chloride, sodium chloride and cryolite (sodium aluminum fluoride) at 1290 F. At this temperature, aluminum diffuses into the nickel layer as it deposits, thus forming the alloy.

An alternative method for plating aluminum has been developed for parts that cannot withstand the high temperatures necessary to operate the cryolite bath. Aluminum is deposited over the nickel at 320 F from a fused salt bath consisting of aluminum chloride and sodium chloride. The coating is then alloyed with the nickel by heating for a few hours in air at 930 to 1110 F.



Nickel-aluminum coating *produced in the sodium chloride-potassium chloride cryolite bath at 1290 F was then heated 2 hr at 1830 F. (500X)*

How they stand up

Steel specimens coated with nickel-aluminum alloy have been tested under many conditions in air at elevated temperatures, in salt spray and outdoors. In air at 1020 F and 1830 F the coatings oxidized at one-tenth the rate of nickel coatings of comparable thickness.

Panels plated from the cryolite bath have the best resistance to salt spray. Panels coated with 2 mils of nickel and 0.5 mil of aluminum have withstood 300 hr in salt spray tests before showing rust. Also, rapid thermal cycling of these panels between room temperature and 1020 F did not affect their corrosion resistance. Best resistance is obtained when aluminum thickness (before alloying) is less than 50% of the eventual total coating thickness after alloying.

Outdoor exposure tests show good correlation with salt spray tests. Alloy-coated panels have exhibited no rust after one year. In contrast, nickel-coated control panels started to rust after four months.

these electrical properties ▶

TABLE 1—DIELECTRIC PROPERTIES OF SILICONE LAMINATES
(Measured at 9 Kmc)[a]

Reinforcement →	Quartz		High Silica Glass[b]		E Glass	
Test Temp, F ↓	Dielec Const (k)	Loss Tan	Dielec Const	Loss Tan	Dielec Const	Loss Tan
75	3.21	0.0026	3.43	0.0250	4.35	0.0060
140	3.22	0.0025	3.47	0.0230	—	—
212	3.22	0.0026	3.49	0.0200	—	—
300	3.21	0.0027	3.43	0.0140	—	—
400	3.21	0.0028	3.33	0.0073	—	—
500	3.21	0.0025	3.28	0.0046	4.31	0.0060
75	3.21	0.0026	3.41	0.0210	—	—

[a]Disks machined to 2.135 in. dia by approximately 0.190 in. (quarter wave) thick; tested in resonant cavity type dielectrometer from room temperature to 500 F and back to room temperature.
[b]H. I. Thompson Fiber Glass Corp.'s Refrasil.

these mechanical properties ▶

TABLE 2—COMPARISON OF MEAN MECHANICAL PROPERTIES[a]

Resin →	Phenyl Silane[b]		Silicone[c]	
Reinforcement →	Quartz	High Silica	Quartz	High Silica
Flex Str, 1000 psi[d]				
75 F	43.2	27.2	34.0	24.1
500 F	37.0	25.0	18.5	13.1
600 F	37.4	19.6	15.8	10.9
700 F	34.5	15.0	13.3	5.4
Flex Mod of Elast, 10^6 psi[d]				
75 F	3.47	2.50	2.60	1.97
500 F	3.05	2.46	2.27	1.57
600 F	3.37	2.35	2.18	1.51
700 F	2.77	—	2.00	1.10
Compr Str, 1000 psi[e]				
75 F	46.6	16.0	22.5	22.1
500 F	32.7	11.4	9.4	7.8
600 F	28.2	9.2	9.2	6.4
700 F	10.9	7.7	5.8	4.9
Ten Str, 1000 psi[f]				
75 F	26.5	18.9	20.5	13.9
500 F	24.1	15.2	17.8	11.2
600 F	14.3	16.0	17.2	9.5
700 F	16.6	9.4	7.8	9.1

[a]Specimens were held for 30 min at temperature before testing at room temperature.
[b]CTL, Inc.'s 37-9X resin. [c]Dow Corning Corp.'s DC-2106 resin.
[d]D790: 1-in. span, 0.025-ipm loading rate. [e]ARTC 11-I test method.
[f]ASTM D638 test method.

show . . .

What Quartz Fiber Can Do for Reinforced Plastics

for use at high temperatures

■ The potential of continuous filament quartz (vitreous silica) roving and fabrics as a reinforcement for heat resistant plastics laminates is approaching realization. The electrical and mechanical property data shown here (based on 181-cloth laminates) indicate that many of the problems of proper finishing and preimpregnation protection of quartz have been solved—or at least that they have been minimized.

An added incentive for broader use is General Electric's recently announced price cut on quartz yarn and roving to $29-$35 per lb, depending on quantity (see M/DE,

Oct '60, p 25).

To date, virtually all quartz fiber used in reinforced plastics has been short fiber reinforcement for molding compounds, although techniques for spinning and weaving the fibers into fabrics were developed about two years ago (M/DE, Feb '59, p 123).

Properties

The accompanying data were developed by Hughes Aircraft Co. from laminates made of GE's quartz fiber and impregnated by U. S. Polymeric Chemicals, Inc. The data should be considered as only indicative, since a small number of specimens was used. Laminates were all made with 181 cloth with A-1100 finish, prepared and press-cured as described in the accompanying table.

Dielectric constant and loss shown in Table 1 for quartz-silicone laminates are extremely low, and particularly promising in their apparent independence of temperature. The table compares quartz-reinforced laminates with a high silica glass (H. I. Thompson Fiber Glass' Refrasil) reinforcement, and a typical E glass laminate.

Mechanical strength data are shown in Table 2. The data compare strength of 181-cloth quartz with 181-cloth high silica glass reinforcements in laminates made with a phenyl silane resin (CTL's 37-9X) and a silicone resin (Dow Corning's DC-2106).

What the data indicate

In all cases, the quartz reinforcement provides surprisingly high strengths. In theory, strength of quartz reinforcement should be higher than that of high silica glass, because the production techniques used to produce the latter tend to result in surface discontinuities on the fiber. However, in the past several workers have reported that photomicrographs of cross sections of quartz-reinforced laminates have revealed a surprising number of discontinuities on quartz fiber surfaces, resulting in relatively poor strengths. Discontinuities are believed to be due to moisture attacking the fiber after it leaves the production bushing and before it is coated with a protective finish. GE's Lamp Glass Dept. is continuing work on the problem, and the data indicate that strengths have been substantially improved.

At present, GE quotes the minimum tensile strength of quartz yarn as 120,000 psi, with the average being about 130,000-133,000 psi. Current work is aimed at a 150,000 psi mean tensile strength. (This compares with a tensile strength of about 200,000 psi commonly quoted for E glass, though much higher strengths have also been reported.

At the target tensile strength of 150,000 psi, the lower density of quartz as compared with E glass (0.079 vs 0.091 lb per cu in.) would make strength-to-weight ratio of the two comparable (1,890,000 in. for quartz vs 2,195,000 in. for E glass). Thus, the much higher heat resistance of quartz could be put to efficient use.

Availability

GE's Lamp Glass Dept., Nela Park, Cleveland 12, Ohio, supplies quartz fiber in the form of CFQ yarn, roving, wool, diamond overlay and matt. The CFQ yarn is 150 1/0 1.0-Z, approximately 200 continuous 0.0004-in. nominal dia filaments per strand, starch-oil (organic) binder, approximately 1.3-1.5 lb per standard bobbin.

The CFQ roving is 12-end O twist, approximately 2400 continuous 0.0004-in. nominal dia filaments, starch-oil binder, 2-7 lb per package.

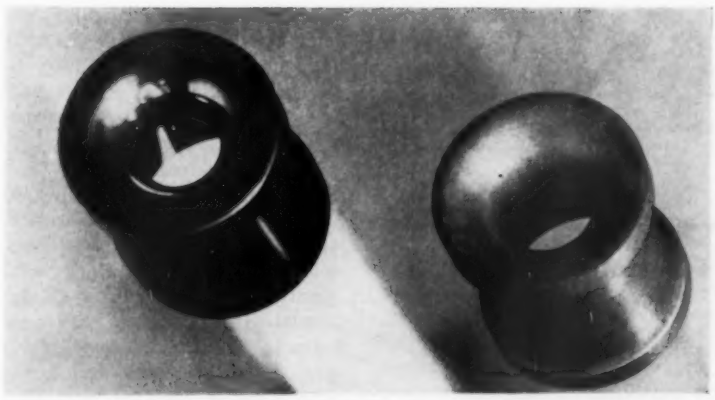
For more information, circle No. 603

How the specimens were prepared—*All laminates were made up using 181 style cloth with an A-1100 binder. Quartz cloth was made from balanced yarn of 150 4/3 ply to a nominal cloth weight of 14 oz per sq yd. Specimens were prepared somewhat differently for the different tests. The table above lists compositions of the different specimens, and the curing and postcure conditions.*

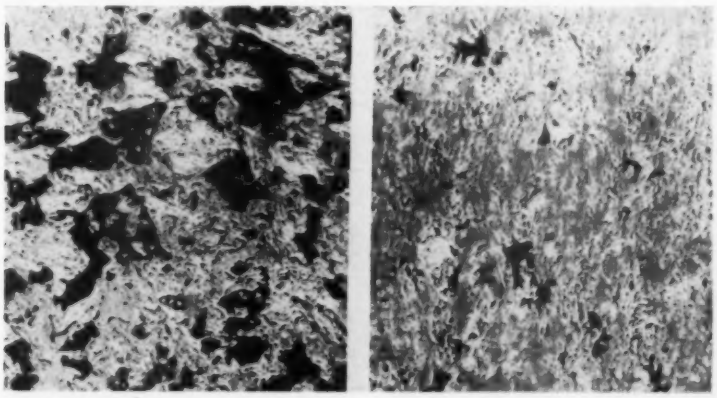
Type of Specimen ↓	Reinforcement		Resin		Pre-Press, min	Cure			Post-Cure		
	Type[a]	No. Plies	Type[b]	Content, %[c]		Time, min	Temp, F	Pressure, psi	Temp, F	Time, hr	Rate of Rise, °F/hr
Flexural	Both	6	PS	30	2	60	280	500	250-550	24	6.25
	Both	6	S	30	2	60	280	500	250-550	24	6.25
Tensile and Compressive	Q	12	PS	30	3.5	60	280	500	—	—	—
	Q	12	S	30	1	30	300	555	—	—	—
	R	12	PS	30	8	80	250	511	—	—	—
	R	12	S	30	1	30	300	511	—	—	—
Electrical	Q	30	S	28.1	1.5	60	300	667	250-550	24	6.25
	R	30	S	28.3	3	60	300	511	250-550	24	6.25

[a]Q = Quartz; R = high silica (Refrasil). [b]PS = Phenyl silane (37-9X); S = Silicone (DC-2106).
[c]Approximate, except for electrical specimens.

New High Density Graphite Looks Good for Rocket Nozzles



***Smooth, metallic look** of recrystallized graphite is contrasted here with a conventional graphite rocket nozzle insert.*



***Definite difference in density** is shown in these photomicrographs (120X) of conventional graphite at left, recrystallized graphite at right.*

■ A new recrystallized graphite with a high density (135 lb per cu ft) and high strength (room temperature flexural strengths of 6000 psi and more) has been developed by National Carbon Co., Div. of Union Carbide Corp., 270 Park Ave., New York.

The material has usable strength at temperatures as high as 5500 F, and exceptionally low creep. It is machinable and is said to have good thermal shock resistance.

The material can be produced in any size and shape. Cylinders as large as 8 in. dia and 10 in. long have been made and 12 by 14-in. parts are anticipated in the near future. Properties can be varied controllably in any or all three directions within the material.

The material has performed exceptionally well in rocket motor nozzles in a variety of tests. According to the producer, it has performed as well as, and in some cases substantially better than, other materials such as tungsten and pyrolitic graphite.

All production of the material has been earmarked for the military for the near future. Although details of the production method have been classified by the Air Force, National Carbon says that the method is "a revolutionary hot working process more akin to metallurgical than ceramic technology."

Property data limited

Conventional artificial graphites range in density up to about 115 lb per cu ft. Only natural and pyrolitic graphite (see M/DE, Aug '60, p 165) have had densities extending to the theoretical density of graphite (141 lb per cu ft), and these are limited in size and geometry, according to National Carbon. Recrystallized graphite attains these densities in massive form.

As is true of other artificial graphites, strength of recrystallized graphite increases with increasing temperature up to about 4500 F. But the new graphite is said to have a much lower creep rate than conventional graphite, extending useful temperatures to about 5500 F.

Thermal expansion coefficient of recrystallized graphite can be controlled over a broad range. Against the grain, a coefficient of 6.7 x 10^{-6} per °F has been attained. On the other hand, low values similar to those of conventional graphites (0.28-1.9 x 10^{-6} per °F) can also be produced. The ratio of thermal expansion with and against the grain is the most sensitive indicator of grain orientation; it can be 25 to 1 for recrystallized graphite, as compared with 3 to 1 for conventional graphite.

For more information, circle No. 604

Developmental V-Cb Alloys Have Excellent Corrosion Resistance

Adding columbium to vanadium also improves strength, oxidation resistance.

by S. T. Wlodek, *Union Carbide Metals Co.*

■ Although vanadium has a high melting point (3072 F) it does not exhibit outstanding high temperature strength. This drawback is offset by excellent room temperature fabricability and ductility down to liquid nitrogen temperature.

Chief disadvantage of vanadium, however, is the low melting point (1220 F) of the principal oxide product, vanadium pentoxide, V_2O_5. The low melting point of the oxide makes hot working of pure vanadium uneconomical and also makes it almost impossible to coat vanadium to decrease the severity of the oxidation problem.

Vanadium-columbium alloys, offering excellent corrosion and oxidation resistance, and high strength, seem to promise a solution. Such alloys are now in the development stage.

Why columbium?

For a variety of reasons, it appeared to us that adding columbium to a vanadium matrix would increase the usefulness of vanadium as an engineering material. Among the reasons for choosing this alloy system:

1. Melting points are high.

2. Columbium is completely soluble in vanadium and, because of large differences in atomic radii, is probably a good high temperature strengthener.

3. Since columbium has a greater affinity for oxygen, it might increase the oxidation resistance of vanadium by promoting the formation of a higher melting point oxide.

Although up to 50% (by weight) of columbium was added to vanadium in this preliminary study, the atomic concentration of columbium is roughly one-half of that expressed on a weight basis. The properties to be described are therefore those of a vanadium-rich alloy system.

Corrosion resistance

Corrosion tests were performed on as-cast specimens of vanadium-columbium alloys over the range 20 to 50% columbium by weight; some alloys also contained titanium additions of up to 20%. Addition of columbium greatly increased resistance to boiling 65% nitric acid; boiling 5%, 10% and 15% hydrochloric acid; and boiling 10%, 20% and 30% sulfuric acid solutions. With the exception of boiling 65% nitric acid solutions, where vanadium-columbium-titanium alloys behaved best, the most corrosion resistant composition studied was the 50:50 vanadium-columbium alloy.

Fig 1 compares overall corrosion resistance of the latter alloy with that of other corrosion resistant alloys by means of a Stern-Bishop bar diagram. In this diagram, the total area below each horizontal bar shows the range of environments in which the material resists attack. Although the diagram is a qualitative one, the overall degree of corrosion resistance of the 50:50 vanadium columbium composition is clear. It has appreciably greater ability to withstand oxidizing or reducing acids in the presence or absence of chlorides.

Oxidation resistance

Tests in pure oxygen indicated that maximum oxidation resistance is developed in vanadium-columbium-titanium alloys with small additions of silicon or aluminum. On the basis of these tests, further evaluation of oxidation resistance was carried out with alloys of the type most likely to show increased oxidation resistance over pure vanadium. Fig 2 shows that even a simple vanadium-columbium-titanium alloy approaches a 500 to 700% improvement in oxidation resistance over pure vanadium. Rate of oxidation of the 45 V–40 Cb–10 Ti–5 Al alloy is excellent. No trace of liquid V_2O_5 was noted for this composition up to 1830 F. The other two compositions in Fig 2 showed traces of the liquid oxide at 1650 F.

Tests, in this case, were conducted in undried static air on ⅜-in. dia specimens. Metal loss is expressed in mils per side decrease in specimen diameter.

Mechanical properties

Mechanical properties were determined on those vanadium-columbium alloys which seemed to have promising corrosion and oxidation resistance. All tests were performed in vacuum on button-head miniature tensile specimens. Results at three temperatures are shown in the accompanying table.

The high mechanical properties of the 60 V–40 Cb and 49 V–40 Cb-10 Ti–1 Si alloys are even more attractive when compared with the properties of other materials on a strength-weight basis. Fig 3 compares the strength-weight

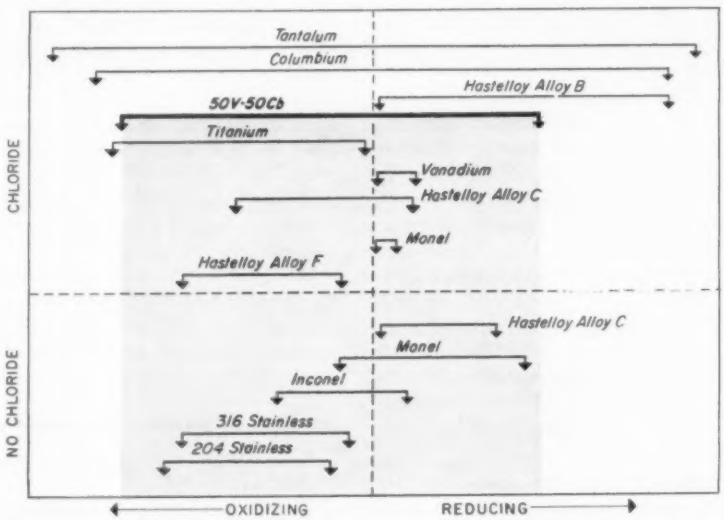
TENSILE PROPERTIES OF VANADIUM-COLUMBIUM ALLOYS*

Comp, %				Room Temp			1290 F			1830 F		
V	Cb	Ti	Other	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
70	30	—	—	Brittle failure			127	91.1	24	—	—	—
60	40	—	—	Brittle failure			102.3	91	7.4	34.8	30.8	8
50	40	10	—	Brittle failure			91.8	84.2	15.8	—	—	—
49	40	10	1 Al	182	140	3	121	88.4	22.3	12.8	8.85	74
45	40	10	5 Al	Brittle failure			91.2	69	5.3	7.9	5.9	142

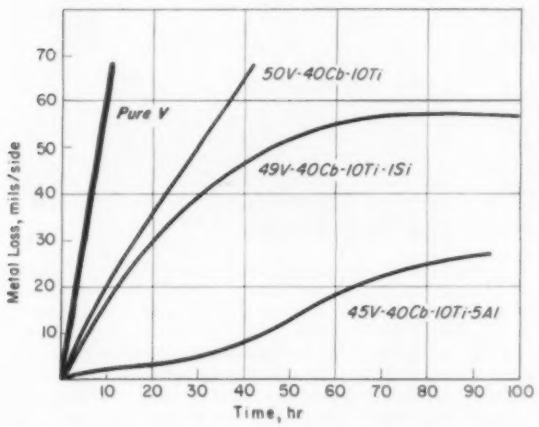
*All specimens impact extruded to 4:1 reduction at 2010-2190 F, then reduced 50% by swaging at 1830 F. Strain rate for all tests: 0.005 in./in./sec.

ratio of these two compositions with similar ratios for the strongest iron, titanium and molybdenum-base alloys. In this plot, the vanadium-base alloys were tested at a strain rate of 0.005 in./in./sec. If data obtained at strain rates of 0.20 in./in./sec are used, the 60 V–40 Cb composition approaches the strength-weight ratio of the molybdenum — 0.5% titanium alloy at 2190 F.

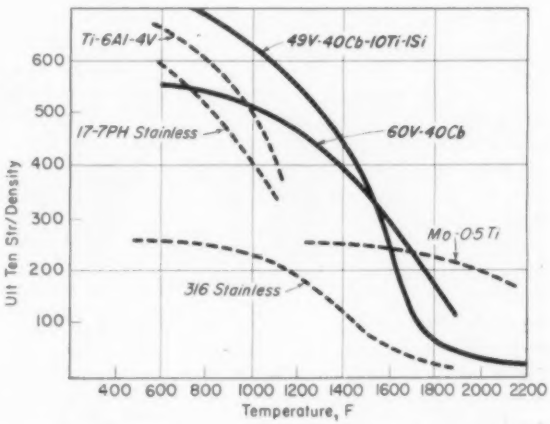
Tensile tests show that columbium additions to vanadium act as solid solution strengtheners as would be expected from the high solubility and maximum amount of lattice strain caused by the difference in atomic radii. The alloys are highly sensitive to strain rate. This condition can be improved by titanium additions but strength is sacrificed.



1—Stern-Bishop diagram shows high resistance of 50:50 vanadium-columbium to oxidizing and reducing atmospheres. Area below each horizontal bar shows range of environments in which material resists attack.



2—Oxidation resistance of three vanadium-base alloys in air at 1290 F.



3—Vanadium-columbium alloys compare favorably on a strength-to-weight basis.

Flame Retardant Coatings for Plastics

Flame protection of combustible or slow-burning plastics in electrical products has become a major design consideration. A good way to solve the problem is to use an intumescent coating.

by B. J. Tyler, *Plastics Application Div., Albi Mfg. Co., Inc.*

■ Many popular plastics that have an attractive combination of low cost and good forming and engineering properties also happen to be combustible. This is a serious challenge to the product designer.

The need for obtaining Underwriters' Laboratories approval and the common desire to insure maximum safety are making it increasingly important that combustible or slow-burning plastics be protected in critical heat and failure locations. Although an obvious solution is to use combustible plastics only at "safe" points, some of these materials offer so much in appliance design that it is worthwhile to find practical methods for using them at critical locations.

Where flame retardance is needed

Four common sources of electrical failure or excessive heat are:

Motors—mixers, fans
Lamps—projectors
Heating elements—dryers
Power tubes—radios, television sets

Although the flame resistance of exterior parts is important, the main concern today is those plastics parts that are susceptible to ignition or combustion from failure or excessive temperature in electrically driven or heated units. Thus, Underwriters' now requires that appliance parts be flame retardant if they are intimately exposed to open terminals or other electrical parts or wiring that carry current.

Remember, however, many appliance parts are only remotely exposed to electricity and can be safely made out of combustible plastics. For example, in commenting on the requirements of its Bulletin 484, Underwriters' says that slow-burning plastics could be used for the grilles of room air conditioners where "no other combustible materials were used on the interiors and away from the electrical system so that any failures in that system would be unlikely to ignite the grille."

Underwriters' does not base its approval on the fire retarding characteristics of individual components but only on the design of the complete appliance. Thus, it is up to the designer to insure that components exposed to heat or electrical failure be made of self-extinguishing or incombustible materials in order to obtain Underwriters' approval of the entire unit.

How combustible plastics can be made fire retardant

A combustible plastic can be made self-extinguishing or incombustible either by incorporating chemical additives or by coating it with a flame retardant material. A flame retardant additive is compounded with the combustible plastic by the supplier of the molding material so that the entire mass of the component will be flame retardant. A flame retardant coating—essentially an intumescent material that swells and bubbles up when exposed to intense heat—is applied to the vulnerable surface of an already-molded com-

Some typical uses for fire retardant coatings

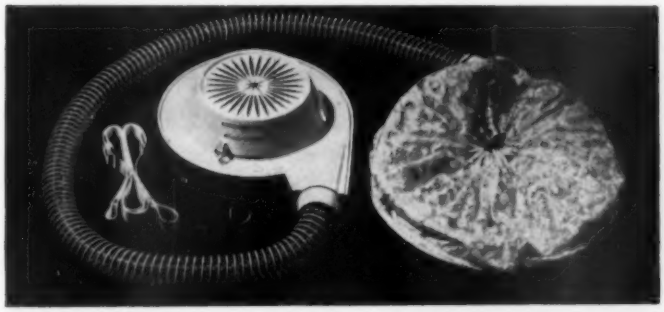
ELECTRIC MIXER

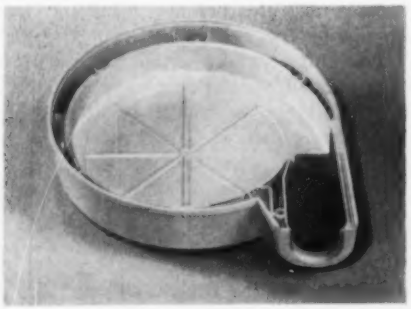
This Sunbeam hand mixer has a case and handle made from a single molding of combustible cellulose acetate. The material was selected for design reasons to replace a metal case used in previous models. It has good molding characteristics, durability, and good surface color and finish. Unlike self-extinguishing grades of acetate, it does not have a disagreeable odor.

Full UL approval for the mixer was obtained by spraying the interior of the case (see photo at right) with a 4-mil thick coating of a UL-listed fire retardant paint (Albi 99). Approval was obtained in spite of the fact that a large percentage of other plastics in the mixer are classified as combustible. The cases are hand-sprayed right after molding at a rate of about 400 pieces per hour.

ponent by the user.

Theoretically, it would appear preferable to use additives and thus make the entire mass of the plastic flame retardant. However, there are disadvantages to this approach. Plastics molders object to the additives because they affect the working properties of plastics during molding: changes in draw strength and forming and distortion temperatures often cause higher rejection rates and need for extra handling. Furthermore, since the



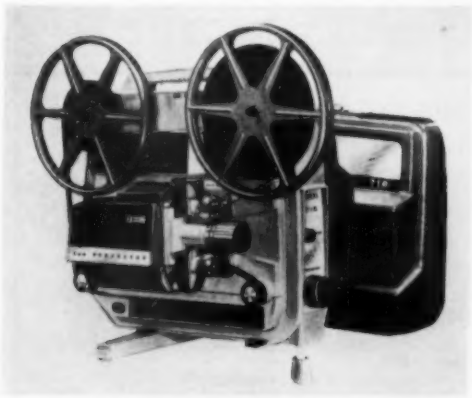


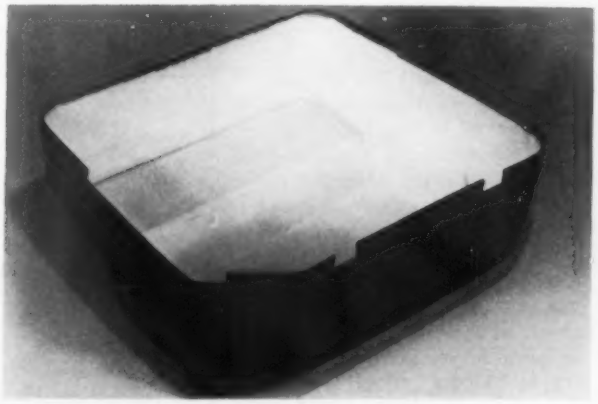
HOME HAIR DRYER

The main housing of this General Electric home hair dryer includes three parts: a plastics base and cover, plus an integral power assembly containing the blower wheel, heating element and control switch. There was no question of flame retardancy for the interior circular surfaces of the cover because the motor is mounted so as to avoid exposed wiring. Similarly, the entire base piece is protected from the power unit by an aluminum plate on which the motor and switch are mounted. However, a need for fire retardance arose because under abnormal conditions the outlet neck of the base might be exposed to the high temperature of the heating element. After considering many materials for the base and cover, selection narrowed down to a styrene-butadiene base plastic and a proprietary plastic containing a chemical additive to make it flame resistant. The proprietary material was eventually rejected because the additive tended to increase the cost of the material and reduce its physical and mechanical properties.

As the photo shows, a flame retardant coating is sprayed on the cover inlet in a uniform thickness of 3 mils or greater (a dark color is used so that the coating is readily visible in production). Thus, the flame retardant coating enabled a superior plastic to be used—and at a net saving of about 20% over a plastic containing additives.

A safety thermostat is incorporated in the dryer to prevent the plastic case from becoming too hot and to prevent the heating elements from burning out if the air outlet should become accidentally blocked. Further protection is provided by a fuse set to open the circuit at 203 F. Thus, the combination of fire retardant coating, thermostat and fuse ensures a high degree of fire safety.





MOVIE PROJECTOR

The housing (a nitrile-butadiene copolymer) of this Revere 8-mm movie projector covers the entire projector, including all electrical connections and fittings as well as the blower which dissipates the considerable heat radiated by the lamp. In order to eliminate fire hazards, the logical design was to use individual shielding for the electrical components or to use a flame retardant coating. Because of its lower production coat, designers decided to use a flame retardant coating over the full interior surface of the housing. Total cost of applying the flame retardant coating is 14¢ per piece—9¢ for materials and 5¢ for labor, based on a production rate of one unit per minute. Thickness of the coating is about 7 mils.

additives have to be added to the entire plastic mass, the fire retardant treatment is usually more complete and expensive than it need be. In contrast, flame retardant coatings can be applied only to critical areas that need treatment, and the choice of plastic is greatly broadened.

The unit cost of plastics parts compounded with flame retardant additives is much higher than the cost of combustible parts treated with flame retardant coatings. Also, flame retardant coatings do not change the properties of the plastic in any way. And, unlike additives, they do not affect the color uniformity or surface finish of untreated areas.

For these reasons there has been a significant increase in the use of flame retardant coatings to protect plastics parts in the past year. Although relatively new, they are already being used on production units of such diverse products as tape reels, portable hair dryers, projector cases, food mixers and built-in high fidelity systems.

How fire retardant coatings work

In addition to providing heat isolation of the plastic and preventing flame spread, flame retardant intumescent coatings also cut down heat transmission to the interior of the plastic and prevent the possibility of ignition. These dual functions are accomplished in this way:

1. Upon exposure to heat or flame at 200 F, the coating puffs up into a thick, sponge-like mat which is entirely noncombustible (a coat only 0.003 in. thick expands to a mat over ½ in. thick).

2. As intumescence occurs, carbon dioxide is released into the area of excessive temperature to blanket off oxygen and dilute any combustible gases already in the space.

3. The cellular mat of minute cells insulates the plastics surface so as to prevent the interior of the material from igniting.

Because of proprietary reasons and pending patents little can be said about the specific chemical composition of fire retardant coatings for plastics. In general, the formulations are similar to coatings for wood products which use organic nitrogen compounds, inorganic fire retardant salts and nonresinous carbonaceous compounds as intumescent agents. Because of difficulties encountered with hygroscopic, acid-forming inorganic compounds such as ammonium phosphate, present coatings for plastics do not contain any inorganic materials, except for

(continued on p 191)

Tests for Flame Retardance

A number of tests for flammability have been developed for proprietary use, industry standards and military specifications. Because the terms *combustible, slow burning, self-extinguishing* and *incombustible* are sometimes used inaccurately, it is often more satisfactory for the appliance engineer to concentrate on whether a particular plastic passes an appropriate test, rather than concerning himself with definitions. Three common tests are now in use for plastics. The third, the direct flame test, is of most concern to appliance engineers.

Refractory panel—In this test a porous refractory panel provides radiant heating of a plastics specimen. Flame resistance is measured by a flame-spread index which is releated to the time for the flame to reach specific points and the amount of heat developed.

Heater-coil—This test is covered in Federal Specification 2023 which requires that the plastics specimen be supported in a heater coil maintained at 1580 F. A spark gap mounted above the heater coil ignites any combustible gases that develop.

Direct flame—This Federal-ASTM test is one of the most important test for plastics appliance parts. A ¾-in. long yellow Bunsen burner flame with no air core is applied to a plastic panel (a total of three panels are used in the test) for 30 sec. It is then removed for 1 min and reapplied for 30 sec. This procedure is repeated at two additional points on the panel. The plastic is judged acceptable under UL standards if it does not continue to burn or smolder at any point for more than 1 min.

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Rules of the Competition: A Brief Summary *(For complete details, see the October issue, pp 123-126.)*

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1960.

3. Provide the following information:

a. A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.

b. A description of the service and/or fabrication requirements that must be met by the product or material(s).

c. A description of the material(s) previously used (if entry is a redesign).

d. A description of the material(s) selected for the entry.

e. An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and non-winning entries. Payment for non-winning articles published will be at usual rates. Judges reserve right to withhold awards at their discretion.

6. All entries must be postmarked not later than *February 1, 1961.*

For description of last year's award winners see May '60 issue, pp 139-162.

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, Materials in Design Engineering, 430 Park Ave., N. Y. 22, N. Y.

Name _____ Title _____

Name(s) of person(s), group or organization who would receive award _____

_____

Company _____

Street address _____ City _____ State _____

Name or brief description of product being entered _____

_____

Was design (or redesign) of entry either completed or placed in production during 1960? _____

Does your employer consent to entry under terms of this competition? _____

Right altitude, wrong magazine

To the Editor:

In reading over your report on "Filament Winding" (M/DE, Aug '60, p 127), I note that one of the references was accidentally attributed to *Aerospace Engineering* instead of *Space/Aeronautics*. The article, "Cheaper and Lighter Rockets with Filament Winding," by R. Gorcey, appeared in our May '60 issue.

IRWIN STAMBLER
Associate Editor
Space/Aeronautics
New York City

Relief of residual stresses in steel, aluminum

To the Editor:

We are currently engaged in a search for information on the relief of residual stresses in steel and aluminum products through thermal treatment. We would like to know the amount of stress relief that can be expected from treating steel and aluminum products to various ranges of temperature for a given time. In addition, we are interested in finding a method for measuring the amount of stress relief for any given maximum temperature and time of heat treatment.

Several graphs giving some of the above information for steel castings and weldments appeared in the "Engineering File Facts" Section of *Materials & Methods*, Nov '46, p 1225. We would appreciate any other information available on this subject.

ROBERT RUNYON
Technical Information Service
Mack Trucks, Inc.
Plainfield, N. J.

We are sorry to say that we have been unable to develop information on the amount of stress relief to be expected. As for techniques, x-ray diffraction stress measurements seem to offer the most promise. The technique is nondestructive and can be used over a wide temperature range. Two good introductory references on the subject are: Residual Stresses in Metals and Metal Construction, *W. R. Osgood, Reinhold Publishing Corp., New York, 1954; and "X-Ray Diffraction for Residual Stress Measurements of Restrained Weldments," E. H. Kinelski and J. A. Berger,* The Welding Journal, *Dec '57.*

Handy way to use indexes

To the Editor:

I see that you have omitted the usual six-month index of editorial features from the June issue of M/DE, but will instead make available a yearly index at the end of the year.

For the past 16 years, I have been discarding

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Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more information, turn to Reader Service card, circle No. 338

the non-indexed material of M/DE and binding six issues into one volume. I keep the indexes in a separate folder and when I need information on a subject, I go through the bound volumes. I hope that your new yearly index will be similar to the old six-month index so that I can continue to save the features.

Incidentally, a summary 10-year index would be useful.

GERRIT DE VRIES
Altadena, Calif.

Help needed on . . . machining acetate

To the Editor:

I would like to obtain information on machining of acetate materials. Specifically, I would like data on feeds and speeds for turning, drilling, forming, etc.

STEPHAN ERICSON
West Farmingdale, N. Y.

For a start, we suggest contacting Eastman Chemical Products, Inc., and Celanese Corp. of America.

. . . suppliers of high temperature metals

To the Editor:

The article entitled "Introduction to High Temperature Metals," which appeared in the June issue of M/DE, p 134, was of particular interest to me. I may have immediate use for some of these materials and I would appreciate any information you have on the names of suppliers of these alloys and on the forms in which these alloys are presently available.

A. S. COUPER
Corrosion Section
Research and Development Dept.
Standard Oil Co.
Whiting, Ind.

The best source of information we know of for suppliers, available forms, properties, fabricability, heat treatment, corrosion resistance, typical uses and other useful data on most of these high temperature metals is our own Materials Selector, *the fourth edition of which will be published this month.*

. . . hydro-spark forming

To the Editor:

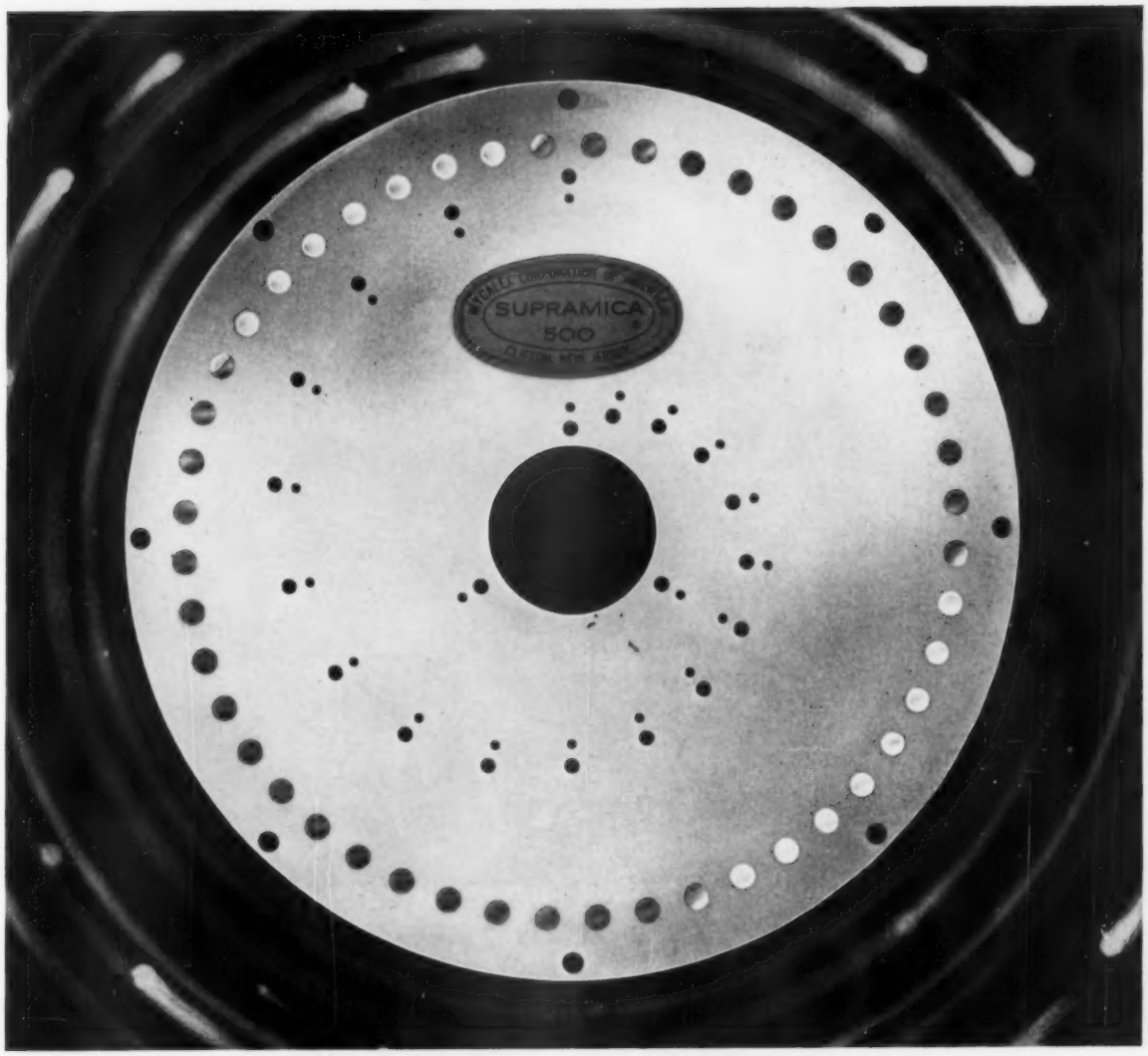
The short discussion of hydro-spark forming which appeared on p 96 of the July '60 issue of M/DE caught our interest and we would appreciate any further information you could send us.

REUBAN M. STRAND
Assistant Superintendent, Plant #4
Chain Belt Co.
Milwaukee, Wis.

We suggest contacting Republic Aircraft Corp.

WIN CASH—Each month $10 will be paid for the best letter written to an author (through us), an editor, or addressed to this column. We reserve the right to withhold awards.

When the requirements seem impossible...



48 precious metal contacts on a 12" circle... maintaining .0003 T.I.R. planar tolerance

To SEE under the sea takes a scanning commutator with seemingly impossible tolerances to insure reliability in ship sonar. That is why compression-molded SUPRAMICA® 500 ceramoplastic machinable insulation was chosen . . . a proud example of MYCALEX CORPORATION OF AMERICA craftsmanship.

The specifications are most demanding, the requirements highly critical . . . plates must be flat within .0003" and embody precision-machined recesses to accept 48 pure silver contacts. The angular displacement of the contacts is held to ±1 minute. The combination of contacts and SUPRAMICA 500 together must accept a 2 micro inch surface finish. The application requires that these tolerances are guaranteed for the life of the commutator during which the environmental conditions run the gamut of humidity and temperature.

The MYCALEX fabricating facility is not only fully qualified to furnish the fabrication of such parts but will design and provide required hardware. For gauge-like specifications on large production runs or short prototype quantities . . . our engineers are ready, capable, and equipped to assist you with your design and production requirements. Write for information on SUPRAMICA ceramoplastics offering maximum temperature endurance (unstressed) up to +1550°F. and SYNTHAMICA® synthetic mica with maximum temperature endurance (unstressed) up to +2000°F. . . . the family of the world's most nearly perfect insulation materials.

General Offices and Plant:
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MYCALEX
CORPORATION OF AMERICA

Executive Offices:
30 Rockefeller Plaza
New York 20, N. Y.

World's largest manufacturer of glass-bonded mica, ceramoplastic and synthetic mica products.

For more information, turn to Reader Service card, circle No. 417

To tint a lady's eyebrow— or make a mirror gleam . . . rely on A+ Felts

Felt is one of the *most versatile* engineering and design materials available. And custom-engineering produces A+ Felts in many forms, each one created to meet the exacting specifications required by its application.

For example, the delicate tip of an eyebrow pencil is made of one type of specially designed A+ Felt . . . yet another type makes the abrasive discs used for high-speed polishing of plate and automobile glass.

Our engineering and research facilities are constantly developing new and improved methods of solving both simple and complex problems with felt.

Learn how A+ Felts can improve *your* application by sending us your design problem. Our engineers will follow through promptly.

Send for this **FREE** informative brochure illustrating the uses of A+ Felt as a design and engineering material.

American Felt Company

Glenville, Conn.

For more information, turn to Reader Service card, circle No. 324

PRICES & SUPPLY

...AT A GLANCE

A 3¢-per-lb cut in the price of copper to 30¢ has been announced by the major producers (Kennecott, Phelps Dodge and Anaconda). At the same time, custom smelters have lowered their price from 31¢ per lb to the same level.

Commercial production of a new line of plastics resins based on butadiene-styrene polymers has been announced by Enjay Chemical Co. Initial plant capacity is rated at 10 million pounds per year. The resins are expected to be used in coatings for appliances, automobiles, pipes, wire and tanks. They were first announced in the spring of 1959 (M/DE, Apr '59, p 136).

A major new source of columbium ore is under development in Canada. Initial plans call for construction of a $1.5 million separation and concentration plant that will have a rated capacity of 500 tons of ore daily. The operating company is St. Lawrence Columbium & Metals Corp. At present, columbium metal sells for about $50 per lb.

Weight of aluminum parts in 1961 cars averages 62.1 lb per car compared to 54.4 lb per car for 1960 models, according to Kaiser Aluminum & Chemical Corp. Primary reason for the increase is the introduction of aluminum engines by all auto companies except Ford and Studebaker-Packard. With the weight increase, aluminum now accounts for almost 2% by weight of the materials used in a car. More details on automotive uses of aluminum are given in the special report starting on page 143 of this issue.

Production of styrene molding and extrusion compounds is slated for a 25% increase when Monsanto Chemical Co.'s new multi-million dollar plastics plant near Cincinnati, Ohio goes into production late next year. High impact and heat resistant grades will be made in the new plant. Actual production figures have not been disclosed.

Look for stainless steel sales to increase 87% over the 10-year period 1957 to 1967, says International Nickel Co. in a recent market research study. The study shows that 1967 sales of stainless steel will be 1,112,000 tons, compared to 592,000 tons sold in 1957.

A 60% increase in tin plate production has been announced by Inland Steel Co. The company has added a third electrolytic tinning line at its East Chicago, Ind. plant. The new installation boosts Inland's tin plate production from 261,000 tons to 435,000 tons annually.

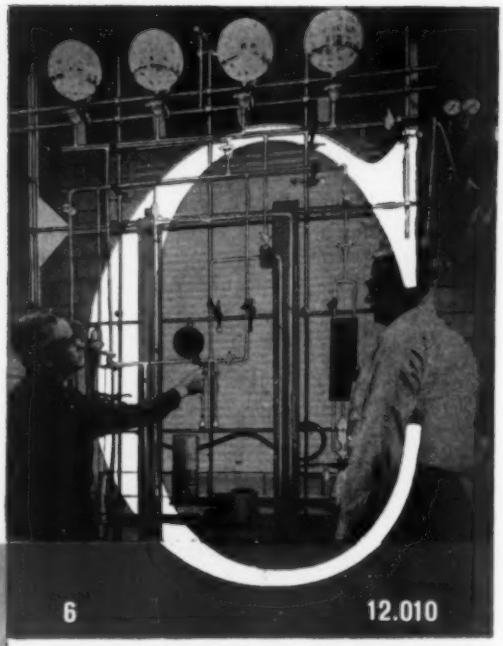
Lower cost pig iron may result from a new technique in which heavy fuel oil is used along with coke in a blast furnace. Tests show that the method can increase capacity and decrease costs of hot metal production. The technique was developed by Esso Research & Engineering Co., an affiliate of Standard Oil Co. of New Jersey.

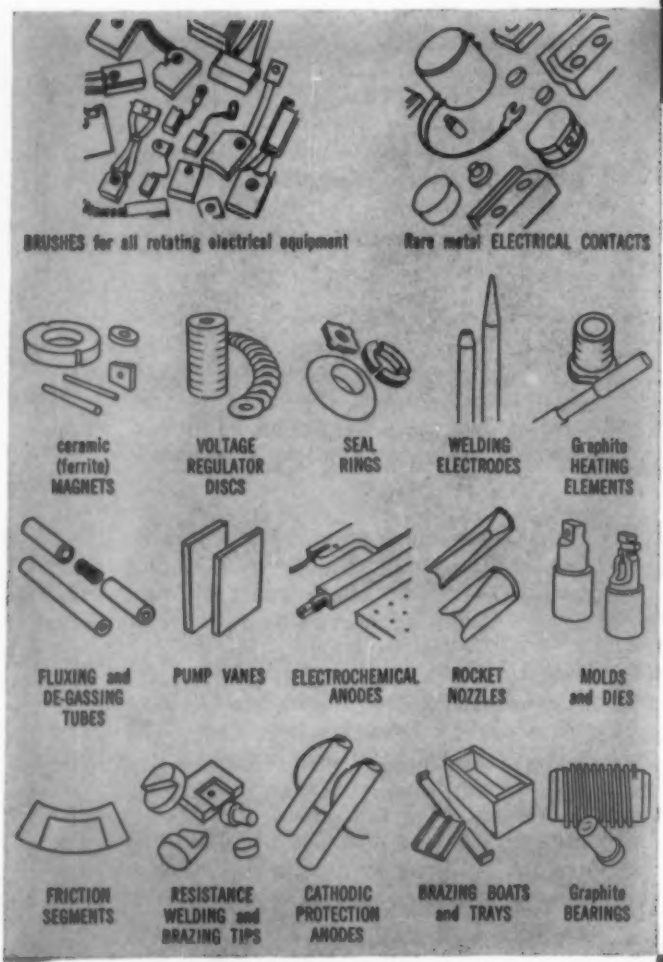
from specialized

Powder Metallurgy Research

. . . new uses and improved materials based on

Nature's Oldest Element





Many of industry's most useful components are made by Stackpole from Carbon and Graphite Powders.

Carbon, its crystalline kin, graphite, and various metal powders are the raw materials of Stackpole Research—a specialized branch of powder blending and molding aimed at developing new uses and improved manufacturing techniques for "Everything in Carbon but Diamonds."

Here, one of many new instruments in the expanded Stackpole Research Laboratories—a nitrogen absorption analyzer — measures powder surface areas as part of a program to develop economical new techniques for milling carbon powders.

STACKPOLE

STACKPOLE CARBON COMPANY
St. Marys, Pennsylvania

For more information, turn to Reader Service card, circle No. 452

GE, Mobay after U.S. Polycarbonate Market

Both General Electric Co. and Mobay Products Co. are now on stream with new plants producing polycarbonate plastics for U.S. industry.

The GE plant in Mount Vernon, Ind. opened in September. Said to be the first fully integrated plant in the United States, it has an annual capacity of five million pounds of GE's Lexan. The $5 million plant is the result of four years of research and is designed so that production can be doubled quickly without expanding existing facilities. Initially, Lexan will be produced in two grades and 14 colors, mostly in pellet form.

Mobay reportedly got into commercial production late in June with a plant in New Martinsville, W. Va. There it is producing an undisclosed volume of its polymer, called Merlon.

Supply up, price down

Price of polycarbonates has dropped to $1.50 per lb in 10,000-lb lots. Bulk availability and lower price are expected to accelerate market development work which is now proceeding rapidly. Both producers estimate that there are already between 200 and 300 applications. Estimates place annual consumption at about 30 million pounds by 1965 (see p 25).

Union Carbide in race?

Union Carbide Plastics Co.'s developmental polymer known as "phenoxy" was believed by many plastics people to be a polycarbonate. It was quietly withdrawn from field testing following GE's announcement.

UCP spokesmen said testing was suspended "after it became evident that the company's patent applications on these materials had been anticipated by the applications of some other firms." According to UCP, several new phenoxy materials in its laboratories are expected to be ready for field testing soon.

The patent picture

GE spokesmen say their patent position is relatively comprehensive. They define polycarbonates as any useful long-chain polymer made up of carbonate groups linked to an aromatic ring in the main chain. (This would apparently include modified homopolymers and copolymers.) GE says it has cross-licensing agreements with Farbenfabriken Bayer AG, which permit both Mobay (jointly owned by Monsanto Chemical and Bayer) and GE to produce polycarbonates under the U.S. patents.

Plastic strong, stable

Polycarbonate resins have high impact strength, dimensional stability and resistance to temperature extremes. Because it is a highly ductile thermoplastic, polycarbonate can be economically pro-

(continued on p 29)

UL Clarifies Curbs on Plastics

Further interpretation of Underwriters' Laboratories' restrictions on plastics in air conditioners comes from the Manufacturing Chemists Assn.

MCA interprets a bulletin dated July 6, 1960 from UL as follows: ". . . if the ignition sources are protected by a metal plate, slow-burning materials can be used anywhere in the air-conditioning unit. Further, the ignition source might be protected by self-extinguishing plastics. In this case, Underwriters' Laboratories would almost certainly want to run tests on the appliance to insure that the self-extinguishing plastic would indeed protect the possible ignition source."

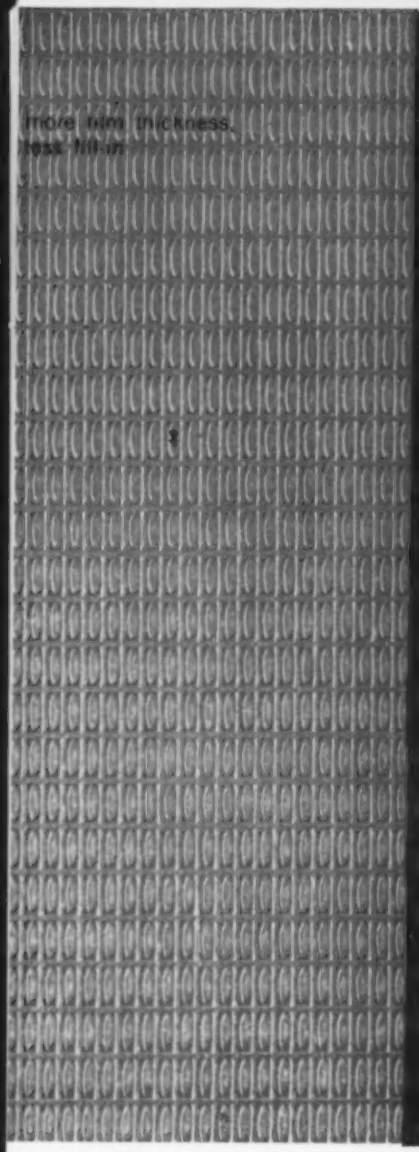
(For background see M/DE, June '59, p 207; July '59, p 192.)

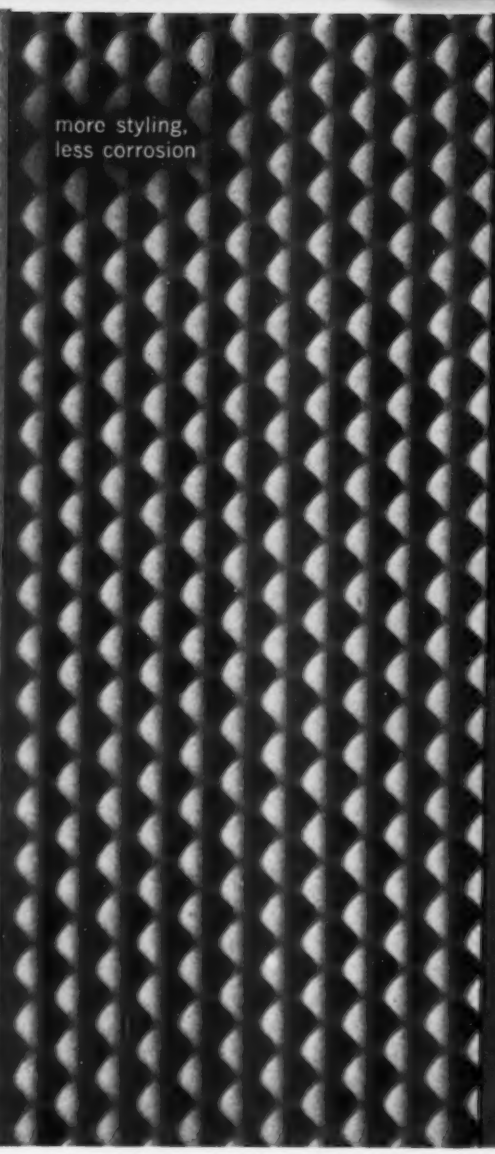
Power Show to Include Materials

New developments in structural materials for the power industry —from plastics to rare and costly metals—will be displayed at the 1960 Exposition of Power and Mechanical Engineering at the New York Coliseum, Nov 28 to Dec 2.

Exhibits will include: improved methods for making extrusions up to 8 in. in dia; centrifugally cast heavy-wall pressure piping for nuclear service; and filled Teflon rings and gaskets.

The show, sponsored by the American Society of Mechanical Engineers, is held in conjunction with its winter annual meeting.





Made for each other... metal plus M&T Spray-on Vinyl Finishes

PATTERN ADDS RICHNESS, STYLE, interesting dimension to metal. And now you can protect, and at the same time faithfully mirror a patterned metal, or add distinctive pattern to smooth metal —thanks to M&T sprayed-on, abrasion-resistant, vinyl finishes.

But these thick-film coatings add more than good looks and warmth. They *multiply* service life because they will not chip, corrode, mar, stain or fade. And since the product is coated at the end of the production operation, there are no unsightly raw edges—no problems with welding and forming. Typical use: automotive interiors.

Two types of M&T vinyl finishes are available: one for application to the mill-patterned or perforated metal of your choice; the other for a leather-like texture on smooth metal. Any color, of course. Send for more data.

M&T coatings and finishes
METAL & THERMIT CORPORATION
General Offices: Rahway, New Jersey

For more information, turn to Reader Service card, circle No. 412

duced by injection or blow molding, extrusion, vacuum forming, and cold forming in standard metal fabricating equipment. Yet its impact resistance is matched only by that of metals or reinforced plastics that lack its versatility.

Excellent electrical properties and transparency have led to many uses in electrical and electronic components, such as precision coil forms. The aviation, automotive and photographic industries also use it widely.

As the basic polycarbonate molecule is arranged with a number of sites available for further reactions, it is possible that a whole family of polycarbonate materials may develop.

Future prospects good

Some indication of the direction future polycarbonate developments might take was given by Dr. R Moody of GE at the plant dedication. He said a number of other forms have already been made experimentally:

1. Extruded copolymer film for electrical applications that raises temperature limits about 104 F.

2. Cast and extruded plasticized film—and a variety of crystalline films. Crystallinity primarily improves heat resistance and tear strength but usually reduces transparency.

3. Polycarbonate fibers, cloth elastomers and fluids.

Product Design Competitions

Five materials design and development competitions have recently been announced. Two are in the plastics field and two are sponsored by the steel industry.

M/DE's 5th Annual Awards Competition for the best use of engineering materials is described on p 19.

Plastics awards

The second Bachner Award competition for outstanding use of plastics in complete units or components is sponsored by Chicago Molded Products Corp. and is administered by the Society of the Plastics Industry, 250 Park Ave., New York 17.

The Bachner trophy will be given to the company whose entry is judged the most outstanding use of plastics. A prize of $1,000 will be presented to the person(s) in the company most responsible for the achievement.

Owens-Corning Fiberglas Corp. has established an annual award competition for the best design application of reinforced plastics.

The first trophy will be presented at the 16th annual Conference of the Reinforced Plastics Div. of the Society of the Plastics Industry at Chicago next February. The competition is administered by the Reinforced Plastics Div. of SPI, 250 Park Ave., New York 17.

Casting, welding awards

An expanded Product Development Contest has been announced by the Steel Founders' Society as part of the centennial anniversary celebration of the steel casting industry in 1961.

Prizes totalling $10,000 will be given for outstanding analysis and design in the applications of steel castings. Entries should be submitted to the Product and Market Development Committee of the Steel Founders' Society of America, 606 Terminal Tower, Cleveland 13.

A $25,000 awards program for progress in arc welded design of machines and structures is being sponsored by the James F. Lincoln Arc Welding Foundation, Box 3035, Cleveland 17.

Thirty-eight awards will be made for the welded steel designs of complete machines or components. Corresponding structural prizes will also be given.

News of Societies

American Society for Testing Materials has elected the following officers: president—Dr. A. Allan Bates, Portland Cement Assn.; and vice president—Russel W. Seniff, Baltimore & Ohio Railroad.

The Society has also honored the following men: Dr. Frank N. Speller received the 7th Max Hecht award for his work in the field of corrosion; Dr. George R. Irwin, Joseph A. Kies and Herschel L. Smith, Jr., U. S. Naval Research Laboratory scientists, the Charles B. Dudley Medal for their paper "Fracture Strengths Relative to Onset and Arrest of Crack Propagation"; Peter J. Serada, Ottowa National Research Council, the Sam Tour Award, given to the author of outstanding merit in the field of corrosion testing methods; and Dr. J. W. Shupe, Purdue University, and W. H. Goetz, Kansas State University, the Richard L. Templin Award for their paper on testing procedures.

Gray Iron Founders' Society honored four industry members at its 32nd Annual Meeting, Oct 13.

Illuminated scrolls were presented to the following: Charles R. Gregg, Gregg Iron Foundry; J. Edward Quest, Shakopee Foundry Co.; J. T. Boyd, Goldens' Foundry & Machine Co. and Albert M. Nutter, E. L. LeBaron Foundry Co.

Lead Industries Assn. is continuing its ceramic research fellowship program with nine projects in the 1960-61 academic year. These range from basic work, such as phase relationships of lead oxides, to applied work, such as improved glazes.

American Standards Assn. delegates will meet in Prague Oct 17-23 with representatives of 20 other nations at the tenth plenary meeting of Technical Committee 61 on Plastics of the International Organization for Standardization (ISO). The meeting aims to establish new international test specifications for plastics.

American Society for Metals dedicated its new national headquarters in Metals Park, Ohio on September 14, 1960.

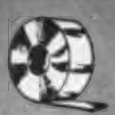
Coming Meetings on p 31 ⟶

NICKELOID IS EVERYWHERE

IN THE LIVING ROOM

IN THE KITCHEN

ALL AROUND THE HOUSE



These eye-catching products use functionally a basic Nickeloid Metal. The finish of Chromium, Nickel, Brass or Copper is electroplated to a base metal, usually Steel (but often Zinc, Brass or Copper).

Mostly, Nickeloid Metals are supplied in continuous coils in widths up to 20" for modern, low cost fabrication. They're also available in sheets and strips. Optional: bright or satin finishes, plating one or both sides, a galaxy of stunning patterns and crimps.

Quality plating produces metals so durable they can be fabricated, even quite severely drawn or beat. Rejects minimized. For severe stamping, we offer Mar-Not protective coating that is easily peeled off after its job is done.

Yes, wherever you go or whatever you do, there is an abundance of useful and prized products on which a Nickeloid Metal gleams, front and center, in full spotlight. Their use at once captures a smart, modern beauty that is durable, easy to keep looking new, and chic. But here is beauty that is more than skin deep . . . Nickeloid Metals are versatile, extremely economical in manufacture . . . deep-down in quality all the way. They are the shopkeeper's delight, the manufacturer's friend, and the designer's inspiration. You can *do so much* with Nickeloid! It's more than a Metal . . . it's a *Method!* Write for free Introductory Kit, including metal samples. Or, phone one of our sales offices (located in most principal cities).

AMERICAN NICKELOID COMPANY · PERU 6, ILLINOIS

America's Pioneer Manufacturer of Pre-Finished Metals — Since 1898

News OF INDUSTRY

Coming Meetings

STEEL FOUNDERS' SOCIETY OF AMERICA, 15th Technical & Operating Conference. Cleveland. Nov 14-16.

MAGNETISM AND MAGNETIC MATERIALS, American Institute of Electrical Engineers and American Institute of Physics. New York City. Nov 14-17.

WIRE ASSN., annual convention. Chicago. Nov 14-17.

AMERICAN SOCIETY OF TOOL AND MANUFACTURING ENGINEERS, Western Engineering Conference & Exhibit. Los Angeles. Nov 14-18.

BLOW MOLDING CONFERENCE, Society of Plastics Engineers, Inc. Newark, N. J. Nov 18.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, winter annual meeting. New York. Nov 27-Dec 2.

POWER & MECHANICAL ENGINEERING EXPOSITION, American Soc. of Mechanical Engineers. New York City. Nov 28-Dec 2.

18TH ELECTRIC FURNACE STEEL CONFERENCE, American Institute of Mining, Metallurgical & Petroleum Engineers. Chicago. Nov 30-Dec 2.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, annual meeting. New York City. Dec 3-6.

3RD NATIONAL CONFERENCE ON THE APPLICATION OF ELECTRICAL INSULATION, sponsored by AIEE, NEMA. Chicago. Dec 5-8.

ATOMIC INDUSTRIAL FORUM AND AMERICAN NUCLEAR SOCIETY. San Francisco. Dec 12-15.

7TH NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL, sponsored by ASQC, AIEE, IRE & EIA. Philadelphia. Jan 9-11.

SOCIETY OF AUTOMOTIVE ENGINEERS, INC., International Congress & Exposition. Detroit. Jan 9-13.

3RD MECHANICAL WORKING CONFERENCE, "Bar & Shaped Products," American Institute of Mechanical Engineers. Pittsburgh. Jan 18.

SOCIETY OF PLASTICS ENGINEERS, 17th annual technical conference, Baltimore-Washington Sec. Washington. Jan 24-27.

SOCIETY OF PLASTICS INDUSTRY, INC., 16th Reinforced Plastics Div. Conference. Chicago. Feb 7-9.

AMERICAN INSTITUTE OF MECHANICAL ENGINEERS, annual meeting. St. Louis. Feb 26-Mar 2.

◀ For more information, circle No 478

In the shape, length, diameter you need:

ASARCON®

Continuous-Cast Bronze Castings

Asarco will custom cast practically all standard tin-bronze alloys in the shapes, lengths, and diameters you need. You get custom shapes in continuous lengths; uniformity and machinability of alloys guaranteed free of hard or soft spots, with no sand, dirt, or dross to dull tools or reduce cutting speeds. You get the superior physical characteristics of continuous cast bronze: impact, tensile, yield strength and hardness, as much as 100% better than the same alloys cast other ways. Write for complete data to Continuous-Cast Department, American Smelting and Refining Company, Barber, N. J. or Whiting, Ind.

Immediately available from stock:

ASARCON 773 BEARING BRONZE (SAE 660) — 260 sizes of rods and tubes. Complete range of sizes from ½" to 9" diameters, up to 105" lengths.

For more information, turn to Reader Service card, circle No. 328

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

CONTINUOUS CAST DEPARTMENT

Bronze part illustrated was machined from a hexagon shaped continuous-cast tube. This custom-cast shape was produced precisely to the customer's alloy, shape and dimension specifications.

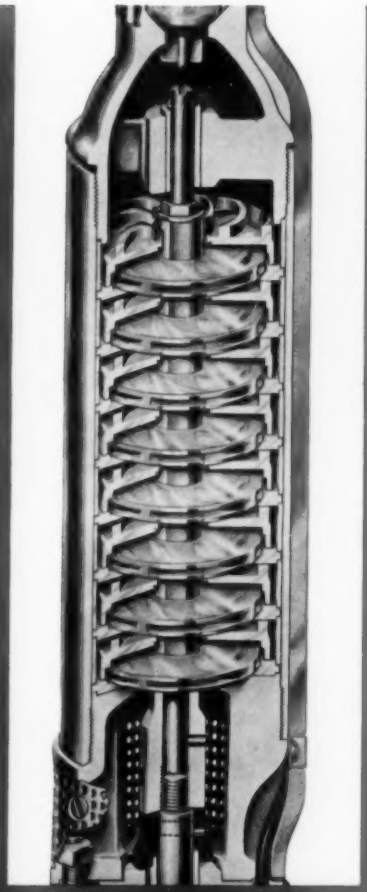
West Coast Distributor: Kingwell Bros., Ltd., 457 Minna Street, San Francisco, Calif. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal. Distributors in many principal cities.

For more information, circle No. 481 ➤

LEXAN®

POLYCARBONATE RESIN

HAS ALREADY SOLVED DESIGN PROBLEMS IN OVER 300 COMMERCIAL APPLICATIONS



LEXAN IMPELLERS stand up where others fail because of Lexan's toughness, low water absorption and resistance to heat and abrasion. Acid, iron and sulphur waters do not halt submersible pumps made by The F. E. Myers & Bro. Co., Ashland, Ohio. (Molded by Michigan Fanstyle Molded Plastics Div. of St. Regis Paper Co., Dexter, Mich.)

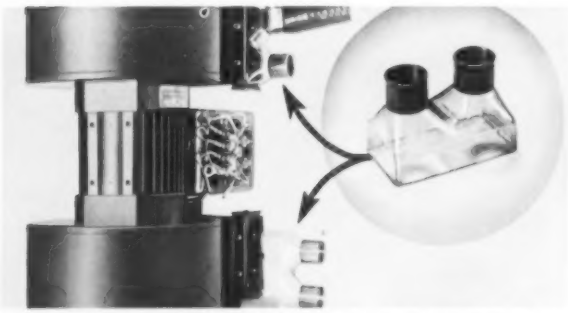
GENERAL ELECTRIC offers you more than 3 years experience in design and fabrication with this tough, rigid thermoplastic

Lexan's exceptional combination of properties includes:

- High impact strength
- Dimensional stability
- Heat resistance
- Good electrical properties
- Creep resistance under load
- Resistance to many chemicals
- Self extinguishing
- Transparent
- Colorable
- High gloss
- High strength at low temperatures
- Non-corrosive
- Oil and stain resistant
- Versatile fabrication

NOW TWO GENERAL ELECTRIC GIVE YOU LEXAN THERMOPLASTICS

HOUSINGS OF LEXAN thermoplastic protect riding lights on the trailing edges of Lockheed's F-104 Starfighter. The transparent resin withstands high friction caused by speeds of 1500 mph, thanks to its exceptional resistance to wear and heat. The material can take high-altitude cold. (Housings molded by Crescent Mold Engineering Corp., N. Hollywood, Calif.)



BLOWER COUPLINGS for radar unit are tough, flame-resistant . . . give smoother air flow than could formerly be obtained with brass fittings. Fabricated of LEXAN polycarbonate resin, they withstand cycling from −54°C to +54°C under humid conditions. They are inexpensively vacuum-formed, allowing considerable savings in machining costs. (Used by the Tracking and Acquisition Radar Equipment Section of General Electric Company, Syracuse, N. Y.)

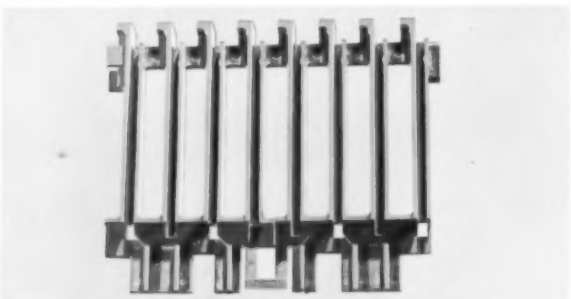
G. E. OPENS NEW LEXAN PLANT

Now, only G.E. offers two-plant flexibility in polycarbonates—a commercial plant and a semi-works plant for continued research and development in polycarbonate resins. The new plant, at Mount Vernon, Indiana, meets the increasing demand for LEXAN resins. The additional capacity, amounting to millions of pounds per year, makes General Electric the largest supplier of polycarbonate resins in the United States!

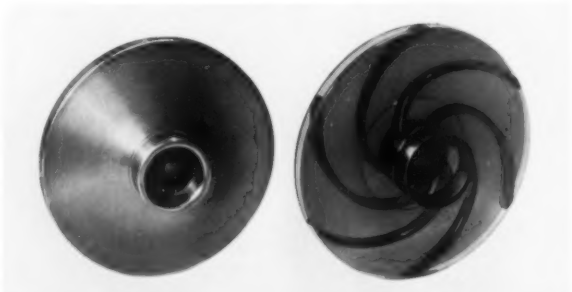
Pioneer in polycarbonates, G.E. has cooperated in the use of LEXAN resin in over 300 commercial applications. You can draw on this experience through G-E Technical Service. For a complete rundown on properties, uses, design considerations, molding and fabricating tips – send for LEXAN technical literature—the most complete literature on polycarbonates available! (*Coupon on page after next.*)

LEXAN—for designs that demand exceptional properties. If you want high strength and heat stability in a thermoplastic, use LEXAN polycarbonate resin. So tough is this material that it can actually be cold-formed and coined like a metal. It withstands over 12 foot-pounds per inch of notch—an impact strength attained by no other plastic. At the same time, LEXAN resin gives you a heat distortion point as high as 290°F! These properties are combined with outstanding dimensional stability, low water absorption, good electrical characteristics and other advantages.

LEXAN resin can be injection molded, extruded, vacuum formed, machined and bonded. It can be made into high-precision moldings, sheet, rod, tube, filament.



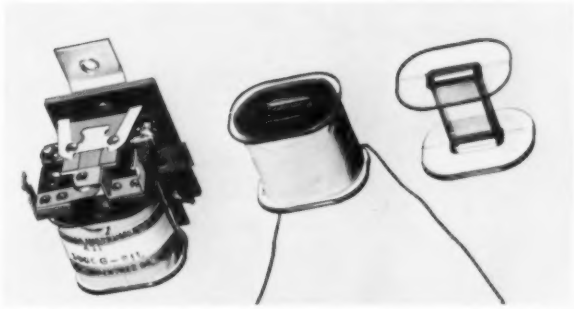
CARD GUIDE requires molding to close tolerances and minimum change in dimensions during service. Molded of LEXAN resin, the part shows excellent dimensional stability under varying conditions of moisture and at high temperatures. LEXAN resin is self-extinguishing—important in this application. (Molded for International Business Machines Corp. by Consolidated Molded Products Corp., Scranton, Pa. and Quinn-Berry Corp., Erie, Pa.)



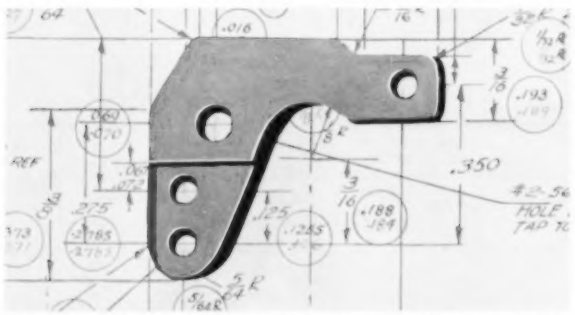
IMPELLERS molded of LEXAN resin replace bronze in jet pumps. Outperforming metal, LEXAN resin gives exceptional impact strength plus ability to withstand 280°F without distorting. LEXAN impellers withstant abrasive wear better than bronze and are unaffected by water or dilute acid. Impeller halves can be separately molded and then solvent-cemented. (Molded for Sta-Rite Products, Inc., Delavan, Wis. by Modern Plastics Corp., Benton Harbor, Michigan, and Santay Corp., Chicago, Ill.)

POLYCARBONATE PLANTS TO SOLVE PROBLEMS LIKE THESE

EMERGENCY-BRAKE BUSHINGS of LEXAN resin help trucks come to a safe stop. Before LEXAN bushings were used, the hole for the piston at the end of the activating cylinder quickly wore oblong, allowing road dirt to enter and cause leakage of the inner seal. The plastic's resistance to wear, heat and grease makes it ideal for this critical use. (Brake manufactured by MGM Brakes, Inc., Cloverdale, Calif. Bushings by Automatic Plastic Molding Co., Berkeley, Calif.)

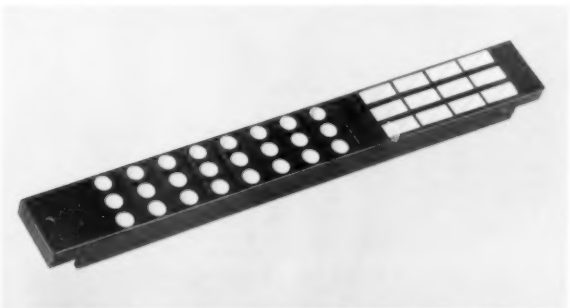


COIL FORM must not distort at temperature above 200°F under stresses caused by tightly wound wire. LEXAN resin provides heat distortion temperatures of 280-290°F under load. A good dielectric, LEXAN resin is resistant to oxidation at high temperatures and is non-corrosive even when used with very fine Class F magnet wire. (Molded for Sigma Instruments, Inc., So. Braintree, Mass. by Waterbury Companies, Inc., Waterbury, Conn.)

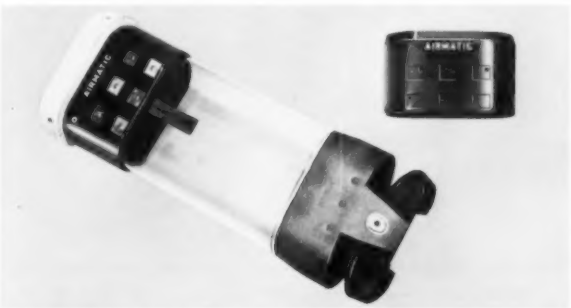


INSULATOR BLOCK of LEXAN resin helps insure trouble-free performance of electrical counter. Not much bigger than a dime, the part must maintain severe tolerances. It takes −85° to +280°F without distortion. The dimensional stability of LEXAN resin lowers cost of the part, permits replacement of materials which required costly machining to attain accurate dimensions. (Molded by Fred Knapp Engraving Co., Racine, Wis., for Abrams Instrument Corp., Lansing, Mich.)

FUSE HOLDER CAPS make use of the transparency and heat resistance of LEXAN polycarbonate resin. Lamp shining through LEXAN cover indicates blown fuse. Plastics previously used softened under the high temperature encountered in naval equipment. LEXAN resin was also selected for its good dielectric properties in the holder, which is rated up to 600 volts and 60 amps. (Molded by B&B Plastics, Oakville, Conn. and Engineered Plastics, Inc., Watertown, Conn. for Fuse Indicator Corp., Boston, Mass.)



LAMPHOLDER TERMINAL BLOCK is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. The part is molded with black resin and painted white in the lampholder holes. (Molded by Booker & Wallestad, Minneapolis, Minn. for Remington Rand Univac Div. of Sperry Rand Corp., St. Paul, Minn.)



"WARHEADS" for pneumatic tube systems take advantage of the high impact strength and dimensional stability of LEXAN resin. The good electrical properties of the thermoplastic permit placement of all electrical control elements in the head. LEXAN resin resists wear and tear and saves cost of repair and replacement in these parts, which undergo friction at speeds as high as 20 mph. (Molded for Airmatic Systems Corp., Saddle Brook, N. J. by Berkeley Engineering and Manufacturing Co., Berkeley Heights, N. J.)

PROPERTIES OF LEXAN POLYCARBONATE RESIN

	Property	Value	A.S.T.M. Test
PHYSICAL PROPERTIES	Color	Light amber, transparent	—
	Specific gravity	1.20	D 792
	Odor	None	—
	Taste	None	—
	Refractive index at 25°C	1.586	—
	Rockwell hardness	M70, R118	D 785
	Abrasion resistance, Taber abraser with CS-17 wheel	7–11 mg/1000 cycles	D 1044
	Impact strength, notched Izod, ⅛" specimen	12–16 ft-lb/in. of notch	D 256
	Impact strength, unnotched Izod, ⅛" specimen	>60 ft-lb/in.	D 256
	Tensile-impact	600–900 ft-lb/cu in.	—
	Tensile yield strength	8,000–9,000 psi	D 638
	Tensile ultimate strength	9,000–10,500 psi	D 638
	Tensile modulus	320,000 psi	D 638
	Elongation	60–100%	D 638
	Compressive strength	11,000 psi	D 695
	Compressive modulus	240,000 psi	D 695
	Flexural strength	11,000–13,000 psi	D 790
	Flexural modulus	375,000 psi	D 695
	Shear yield strength	5,400 psi	D 732
	Shear ultimate strength	9,200 psi	D 732
	Light transmission (⅛ in. thick disc)	75–85%	—
	Water vapor permeability	3–4 x 10^{-8} g/cm/hr/cm²/mm Hg	—
	Nitrogen permeability	0.012 x 10^{-8} cc(STP)/mm/sec/cm²/cm Hg	—
	Carbon dioxide permeability	0.32 x 10^{-8} cc(STP)/mm/sec/cm²/cm Hg	—
	Bulk factor of pellets	1.7	—
	Poisson's ratio	0.38	—
	Modulus of rigidity	116,000 psi	—
	Deformation under load, 4000 psi 77°F	0.2%	D 621
	158°F	0.3%	
	Fatigue endurance limit (Wohler method), 1800 cycles/min., 73°F, 50% RH	2000 psi	
	Water absorption, 24 hr. immersion	0.2%	D 570
	equilibrium 73°F	0.35%	
	equilibrium 212°F	0.58%	
THERMAL PROPERTIES	Heat distortion temperature	264 psi: 280°–290°F 66 psi: 283°–293°F	D 648
	Mold shrinkage	0.005–0.007 in./in.	D 955
	Thermal conductivity	4.6 x 10^{-4} cal/sec/cm²/°C/cm	—
	Coefficient of linear thermal expansion	3.9 x 10^{-5} in./in./°F	D 696
	Flammability	Self extinguishing	D 635
	Brittle temperature	<−135°C	D 746
	Specific heat	0.30	Bulletin 157
	Deformation under load on 0.5 in. cube	Temp., °F: 158, 158, 77, 77 — Load, lb: 1000, 500, 1000, 500 — Deformation, %: 0.282, 0.080, 0.220, 0.101	D 621

		−30°C	−3°C	23°C	100°C	125°C	A.S.T.M. Test
ELECTRICAL PROPERTIES	Dielectric constant						
	60 cycles	3.12	3.14	3.17	3.15	3.13	D 150
	10^6 cycles			2.96			D 150
	Power Factor						
	60 cycles	0.005	0.004	0.0009	0.0009	0.0011	D 150
	10^6 cycles			0.010			D 150
	Volume resistivity, ohm-cm	>10^{17}	>10^{17}	2.1 x 10^{16}	2.1 x 10^{15}	2.7 x 10^{14}	—
	Arc resistance,						D 495
	stainless steel strip electrodes			10–11 sec			
	tungsten electrodes			120 sec			

	25°C	100°C	A.S.T.M. Test
Dielectric strength, short time	3,910 v./mil at 1.5 mils 3,080 v./mil at 3.0 mils 2,560 v./mil at 4.7 mils 1,130 v./mil at 23.0 mils 400*v./mil at 125.0 mils	3,380 v./mil at 3.0 mils 1,250 v./mil at 23.0 mils 600*v./mil at 125.0 mils	D 149
Resistance to electron beam radiation	No change up to 5 x 10^7r dosage		

(*The step-by-step values are essentially the same as the short time values for the 125-mil pieces)

Chemical Materials Department, Section M-1
General Electric Company, Pittsfield, Mass.

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CASE HISTORIES FROM MT. VERNON FILES

Subject:

The Black & Decker Manufacturing Company, TOWSON, MARYLAND

This new B & D "Servicemaster" Polisher—and its companion Sander, each of which sells for only $65. —contains outstanding features formerly found only in higher priced units: heavy-duty ball bearings; spiral bevel gears; recessed toggle switch, protected from dust; rugged lightweight aluminum housings.

Advanced design, which took into consideration most of the inherent advantages of high-pressure aluminum die casting, resulted in considerable manufacturing economies and an ultimate *low price tag*.

Conventional design on the regular B & D line uses 5 castings: 1-a gear case 2-a gear case cover 3-a main field case 4-a switch handle 5-a switch handle cover. In the new B & D design concept *5 parts have been combined into 2 clam-shell castings* which weigh only 2 pounds 3 ounces, a weight reduction of approximately 2 pounds over similar type polishers... the new complete "Servicemaster" polisher weighs only 8¼ pounds.

Fewer parts, however complex, mean reduction in secondary assembly operations. But despite intricate design...the superior skill of Mt. Vernon craftsmen has assured Black & Decker a steady supply of highest quality aluminum castings, economical, excellent fitting...excellently finished...requiring the least number of finishing operations.

Perhaps, like Black & Decker, you too have a cost problem. Product design with our assistance may be your answer. Let's talk it over. Just call your nearest Mt. Vernon sales representative for action.

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NEW DESIGNS IN MARLEX

Meals stay hot . . . thanks to molded covers and thermoformed trays of MARLEX*

This popular new HOT-PAK Tray Server, marketed by Mealpack Corporation of Evanston, Illinois, for its hospital dietary systems, shows how effective MARLEX High Density Polyethylene is for consistently accurate thermoforming of large items. For its HOT-PAK Server, Mealpack Corporation needed a dome cover and a tray that would resist cracking, denting and chipping . . . remain color fast and free from warping when subjected to the boiling temperatures and strong detergents of institutional dish washers. Also, it was important that the cover and tray fit perfectly with one another to produce a vacuum seal and to keep heat loss at a minimum.

MARLEX was the answer for both the injection molded cover and the thermoformed tray. The large trays, economically thermoformed on a fast cycle time from ⅛-inch sheets of MARLEX 6002 Resin, are attractive with color molded in. They are virtually unbreakable, capable of withstanding temperatures as high as 250°F and as low as —180°F, lightweight, free from corrosion, durable, and unaffected by most acids, chemicals and oils. Covers molded of MARLEX 6050 Resin also possess these superior physical characteristics.

Products made of MARLEX combine light weight, strength, rigidity, toughness and resilience, with resistance to acids, solvents, alkalies, detergents and oils. They are non-absorbent, non-allergenic and waterproof. MARLEX items can be injection molded, thermoformed, extruded . . . machined and printed upon. In fact, no other type of material serves so well and so economically for so many diverse applications. For details on MARLEX and how it can serve you, contact the nearest office listed below.

*MARLEX is a trademark for Phillips family of olefin polymers.

Tray is thermoformed by General American Transportation Corporation, Chicago, Illinois. Cover is injection molded by Lincoln Molded Plastics, Circleville, Ohio.

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma, a subsidiary of Phillips Petroleum Company

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Joe Foster, President,
talks about Foster Grant's
unique experience
in plastics.

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At Eastman you can find plastics to shape a new world of products

Ideally suited to modern high-speed vacuum-forming techniques, Tenite plastics are cutting costs sharply for many manufacturers

Vacuum forming—one of the oldest techniques of fabricating plastics, but only in recent years adapted to speedy modern methods—is now in the foreground of interest as an important method of shaping plastics products for today's market.

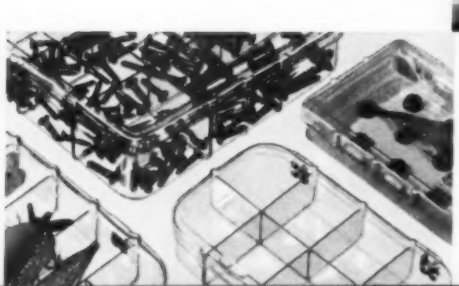
Starting material for a vacuum-forming operation is an extruded thermoplastic sheet. In simplest terms, vacuum forming involves only two steps, both performed on the same machine. The first step consists of clamping the flat sheet of plastic in a frame above the waiting mold and heating it (with built-in heaters) to the required forming temperature. In the second step, the heated sheet is brought down into close contact with the mold, suction is applied, and atmospheric pressure then forces the heat-softened sheet over and into the contours of the mold.

Sheet extruded from any of the Tenite plastics is well-suited to vacuum forming. Typical commercial products made of these plastics are shown on these pages. They illustrate the diverse shapes and uses to which vacuum forming can be adapted. An outstanding advantage of the Tenite cellulosics—Tenite Butyrate, Tenite Propionate and Tenite Acetate—is their low specific heat which speeds both heating and cooling. Sheet of these plastics can be formed quickly and economically into tough, lightweight, highly impact-resistant products of enduring luster.

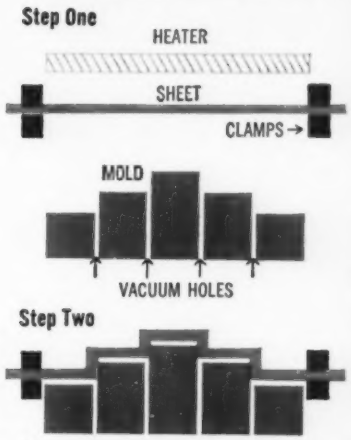
For products that are to be used outdoors, special formulations of Tenite Butyrate are available which provide excellent weather resistance and dimensional stability.

Tenite Polyethylene and Tenite Polypropylene are other Eastman plastics useful in vacuum forming. While slower to heat and cool than sheet of the cellulosics, these can be more satisfactorily formed in molds with sharp angles and offer many physical and chemical properties useful in housewares, industrial products, toys and packaging.

All Tenite plastics are available in a virtually unlimited range of colors. Over the years, the Tenite Color Laboratory has developed formulations in almost 43,000 different colors and color effects. For many applications, colored sheet can be used to yield an integrally colored product, eliminating the need for a separate decorating or painting operation. In other applica-



HOW VACUUM FORMING WORKS



NOTE: The above diagrams depict a simple vacuum-forming operation. There are many variations of this method, including some in which air pressure or mechanical pressure replaces the use of a vacuum.

tions, such as signs, clear-transparent sheet may be used, with the decoration being applied either before forming (by use of distortion printing) or after forming. It should be noted that even shapes which at first appear impossible to vacuum form can be produced by this method. For example, by using a "plug-assist" (to permit a deep draw), wastebaskets 8½" in diameter and 11½" deep have been vacuum formed from sheet of Tenite Butyrate. Similarly, spherical globes for toys and outdoor lanterns have been produced at low cost by vacuum forming two hemispheres and then solvent-cementing them together.

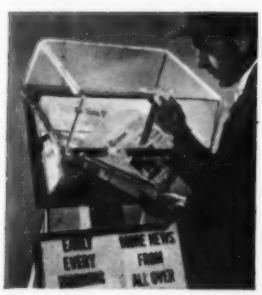
An important advantage of vacuum forming is the low cost of the necessary molds . . . often only 1/20th to 1/10th as much as those for injection molding. As a matter of fact, very inexpensive molds can be cast from plaster or tooled from hardwood or pressed wood to use on test runs, developmental designs, or single or short-run production.

The obvious economies inherent in vacuum forming have helped the technique win quick favor in many fields. In the manufacture of outdoor signs, displays, toys, housewares, decorative and lighting panels, vacuum forming is now a leading production method.

Vacuum forming also makes possible the rapid packaging of merchandise in bubble, blister or skin packs. Here, short heating and cooling cycles are particularly important because of the high speeds at which the packaging machines operate.

Perhaps vacuum forming with Tenite plastics could help you cut costs or speed production of some item you are now making or planning to make in the future. We'll be glad to help you explore its advantages and evaluate its merit.

The comprehensive story of how Tenite plastics are being used in this new manufacturing process is told in a 20-page booklet, "VACUUM FORMING." For your free copy, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENN.



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Easy-processing SBR rubber	194	611
Seven new polyester resins are tough, easy handling	208	624 to 629
Fast curing phenolics	218	632
Reinforced gasket materials are heat resistant	220	633 & 634
OTHER NONMETALLICS		
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New semiconductors	202	619 & 620
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9	34	59	84	109	134	159	184	209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684
10	35	60	85	110	135	160	185	210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685
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You simplify inventory and materials-handling. You save money in purchasing and production, too.

• 4340 stands alone among medium-carbon steels in its ability to provide maximum strength, ductility, toughness and resistance to fatigue in parts of medium to heavy section.

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Holding the Shippingport nuclear reactor's top head to its shell section is a job performed by 42 studs of AISI 4340. This through-hardening nickel steel provides essential strength and toughness.

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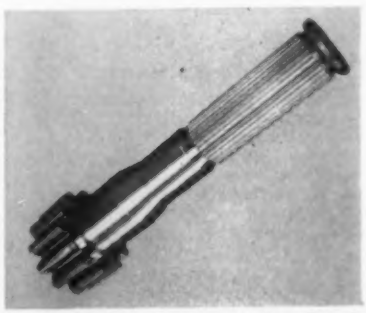

Swing shaft for giant power shovel made from 4340 nickel alloy steel for strength and toughness to take shock-loading in stride. This 9"-diameter, 36"-long shaft of 4340 nickel alloy steel transmits tremendous torque to a giant ring gear.

Sustained accuracy is assured in this heavy-duty milling machine by spindle and gear components of AISI 4340 and 4620 nickel alloy steels. They provide needed strength and wear resistance.

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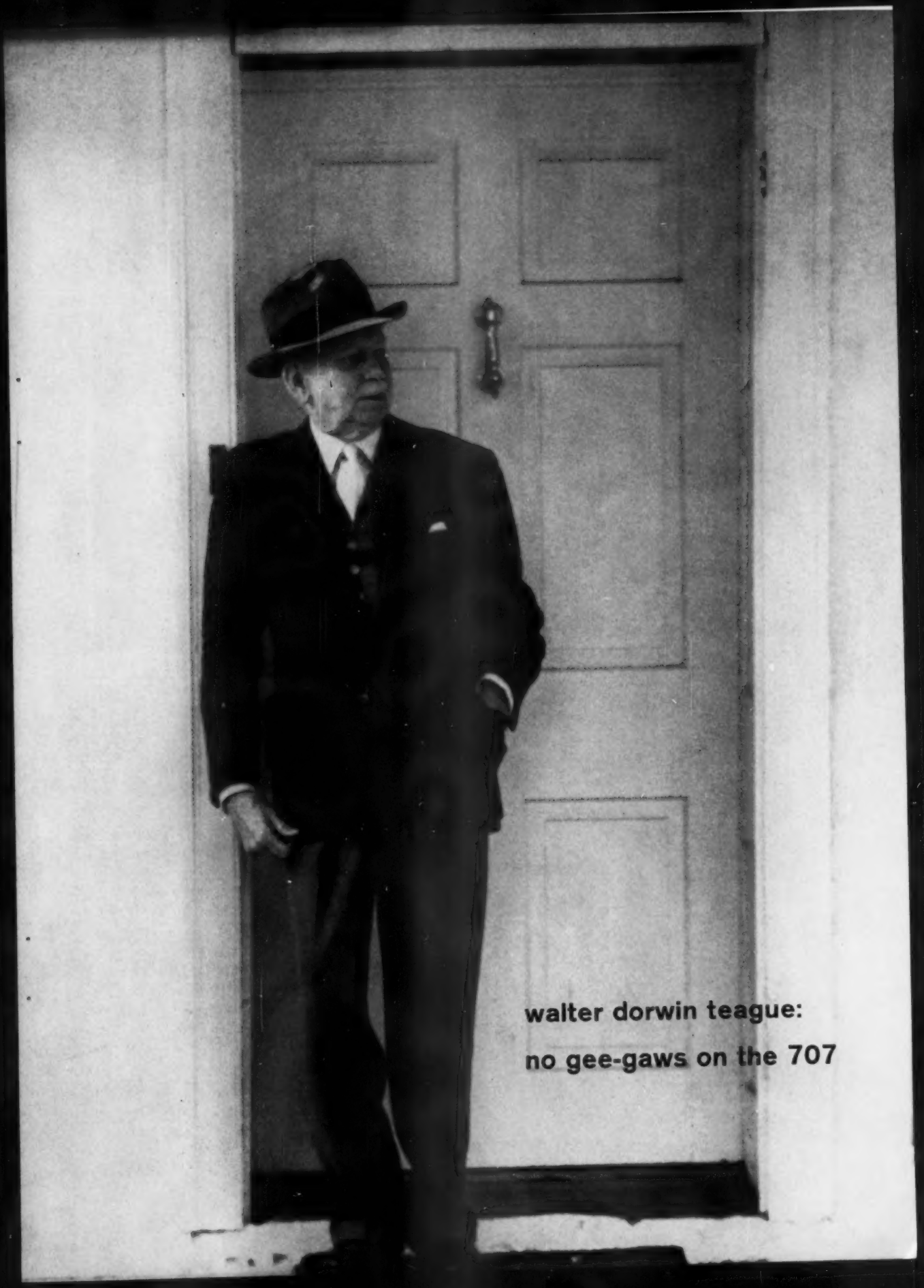


walter dorwin teague:
no gee-gaws on the 707

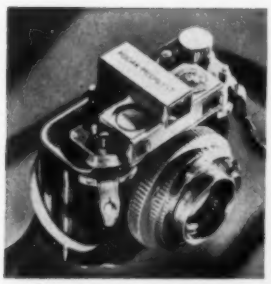
teague talks design

In 1942 a man named Walter Dorwin Teague published "You Can't Ignore Murder," a mystery novel. It is probably the only attempt at bafflement in his long history, because Walter Teague has been making products speak clearly for themselves since the Twenties.

Teague has rightly been called the dean of industrial design. He began as an artist in 1908 designing advertising, books and magazine illustrations. If you're old enough to remember Locomobile and Pierce Arrow ads, Teague designed them. In 1927, Eastman Kodak asked him to redesign their cameras. He made a proposal to spend one week a month in their plant observing production problems and techniques, and *then* redesign the cameras. That simple principle of knowing how a product is made, of understanding all the complexities of the production line, is still a Teague trademark. And Eastman Kodak is still a Teague client.

In the thirty-plus years since that camera assignment, Teague has explored just about every nook and corner of the wonderful world of three dimensions. He designed the classic Marmon 16 automobile in 1930, with his son as collaborator; he was on the Design Board of the 1939 World's Fair. When World War II exploded, the Navy asked Teague to perform design work on their 16-inch guns in order to eliminate possibilities of explosions caused by loading malfunctions. Today he still works for the Bureau of Ordnance. He has 120 people in his organization, a branch in San Juan and task forces scattered across the United States

Teague has designed service stations, railway equipment, plane interiors, heating appliances, business machines and machine tools, offices and furniture, showrooms and department stores, even periodicals. One of the most impressive things he has done is the Boeing 707 jet interiors. Mr. Teague recalls: "Boeing was concerned about their ability to sell the 707 because they hadn't made civilian planes for years. We convinced them to build a full-size mockup of the interior. They gave us *carte blanche* with body engineers to collaborate, and they refused to look at it until it was finished. We made it complete to the tiniest detail. It cost half a million



dollars and helped in selling most of the huge fleet now in the air. Our staff is responsible for the final interiors of the planes purchased by eighteen or more airlines, and for the interiors of executive planes purchased by the United States Government."

Whether mammoth jet airliners or chairs, a product is designed to five principles that are the *modus operandi* of the Teague organization. "First of all, the redesigned product has to work better for our efforts," Teague says. "It should be more convenient to use, more humanized. It must make honest use of the material it's made of, and it's got to be capable of being efficiently manufactured at the proper price. We assiduously avoid gee-gaws or extraneous ornamentation that adds nothing but price to the product. Finally, the design must give the user an emotional pleasure or gratification each time it is used." Selection of the right material for the job is important to each of Teague's requirements. "We endorse no material over another," Teague says. "We first look for the material that is best in keeping with the product's desired personality. Strength and durability are highly important in material selection. Then we make sure our client's tooling can handle the material we have in mind. Above all, it takes the right material to sell the product to the consumer."

Teague has used practically all materials known to man and it is no accident that a great many of his designs use steel in one way or another. "The wonderful thing about steel is its versatility," says Teague. "Its many alloys, old and new, give it adaptability that other materials don't have. Its strength, both in tension and compression, qualifies it for literally thousands of uses. And stainless steel is another reason why steel is a modern metal because it gives so many designs their contemporary look."

The moral is this: steel is an ageless metal, as much at home in the Boeing 707 and today's elegant tableware as it was in medieval days. Its enduring modernity will always be recognized and used by designers like Walter Dorwin Teague.

USS TRADEMARK **United States Steel**

designing with stainless steel

The ideal design has been described as one in which the properties of the material are fully utilized in the finished product. This ideal is difficult to achieve, and no group of materials comes as close to permitting this ideal as stainless steel.

To put it differently, no other material combines so many outstanding properties as the stainless steels. Stainless steels have high tensile strength. All are hardened and made even stronger by cold working. As a family they offer superb resistance to the corrosive effects of an enormous variety of reagents. They have unusual resistance to high temperature oxidation, and are distinguished by relatively low heat conductivity. And on top of their remarkable physical properties, stainless steel's lustrous appearance and sales appeal scarely need mention.

There are over 30 types of stainless steel today.

The history of stainless steel's use is marked by designers who turned a healthy profit with a quality material but mainly with sound ideas. They're the men who used stainless for its strength and sales appeal in toaster covers, its appearance and machinability in wrist watches, its structural properties and cleanability for truck trailer parts. Stainless steel cuts weight and adds years to the life of architectural panels; its corrosion resistance and smooth, pocket-free surface have made it the standard of the dairy industry. There are literally thousands of applications of stainless steel in which designers have utilized one, two or more of the remarkable properties of stainless steel.

By reflecting the color of its surroundings, stainless steel contributes to harmonious design.

Types 302, 410 and 430 make up 75% of stainless steel's uses.

Good design is honest design, whether it uses stainless steel or other materials. Yet the fact remains that there is no other commercial material quite as versatile as stainless steel. The applications shown on these pages are just a few of the hundreds of uses to which stainless is put every day. To learn more about stainless steel and its design properties, call our nearest sales office or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

Successful designers don't substitute stainless steel sections for sections of other materials. They design to stainless' unique properties.

Good design doesn't stop with function and sales appeal. It must also be capable of economical manufacture. As a comprehensive guide, send for the free book described at the right.

Stainless steels represent but a few of the thousands of grades of steel in existence today. United States Steel makes a complete line of stainless steels as well as alloy, high strength and carbon steels. Bring your design problems to us.

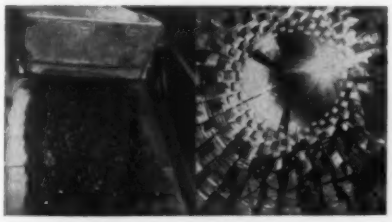
USS is a registered trademark

USS United States Steel

No Material comes close to stainless steel's versatility. By way of illustration, here are a few "opposites" that prove our point.

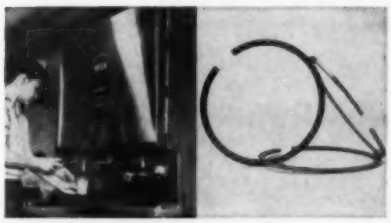
HOT. Temperatures in a jet afterburner reach 1400°F.

COLD. Stainless heat exchanger operates at temperatures as low as —443°F.



WET. Combination of moisture and coal would corrode nearly anything but stainless.

DRY. Rotary dryer is used to dry pharmaceutical ingredients.

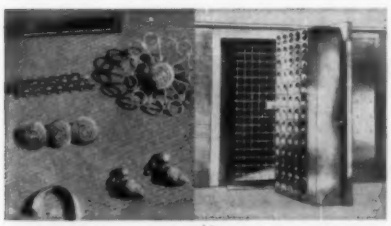


CLEAN. Milk dispensers of stainless steel prevent contamination.

DIRTY. Stainless piston rings resist high temperature corrosion.

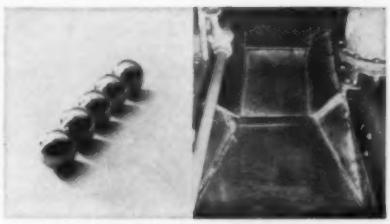
INSIDE. Chemical tanker needs simple wash-out for cleaning.

OUTSIDE. Stainless automobile trim stays bright and good-looking.



LIGHT. Stainless steel jewelry has a light, graceful appearance.

HEAVY. Strength and hardness of stainless combine to make safe doors safe.

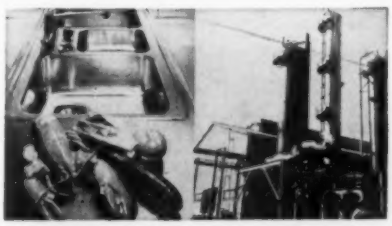


ROLL. Stainless ball bearings take a lot of punishment.

SLIDE. Abrasion resistance of stainless steel makes chutes last longer.

FORM. Stainless steel wrist watch keeps time and beauty.

FUNCTION. Stainless steel muffler defies heat with silence.

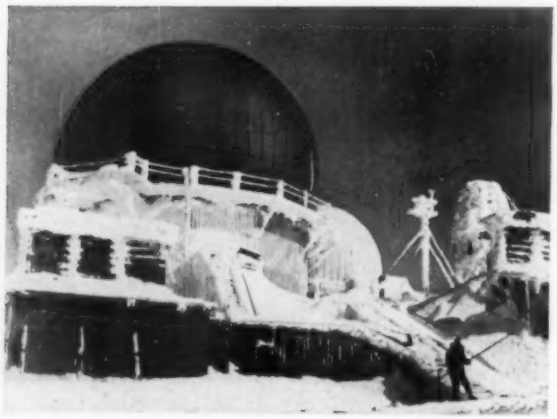


WATER. Stainless sinks stay bright and beautiful.

FIRE. Stainless steel shingles inside cat crackers are red hot.

This mark tells you a product is made of modern, dependable Steel.

In Arctic cold...

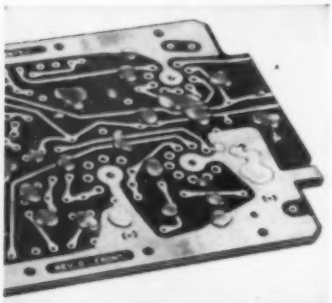


General Electric Silicone Fluids offer reliability from —65°F to 400°F as liquid dielectrics and heat transfer media in aircraft, missiles and ground installations. Excellent dielectric properties are virtually unchanged over wide ranges of temperature and frequency.

or missile heat...

G-E Silicone Rubber Insulation is used in missiles and space vehicles because of its excellent insulating properties, resistance to temperature extremes, moisture and ozone and its long-time stability in storage.

G-E silicone insulations do the job!



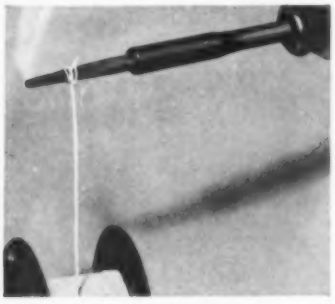
RTV* Liquid Silicone Rubber comes in a wide range of viscosities for potting, encapsulating, impregnating and sealing. RTV resists heat, cold, ozone, moisture; protects against high-altitude arc-over.
*Room Temperature Vulcanizing

G-E Silicone Varnishes provide excellent protection against moisture and high operating temperatures. Applications include conformal protective coatings for printed circuits, resistor coatings, transformer impregnation, etc. New varnishes cure at low temperatures.

New Silicone Dielectric Greases maintain physical and electrical properties from —65°F to 400°F, offer protection against moisture and oxidation. Used as corrosion inhibitors, lubricants, heat transfer media and release agents.

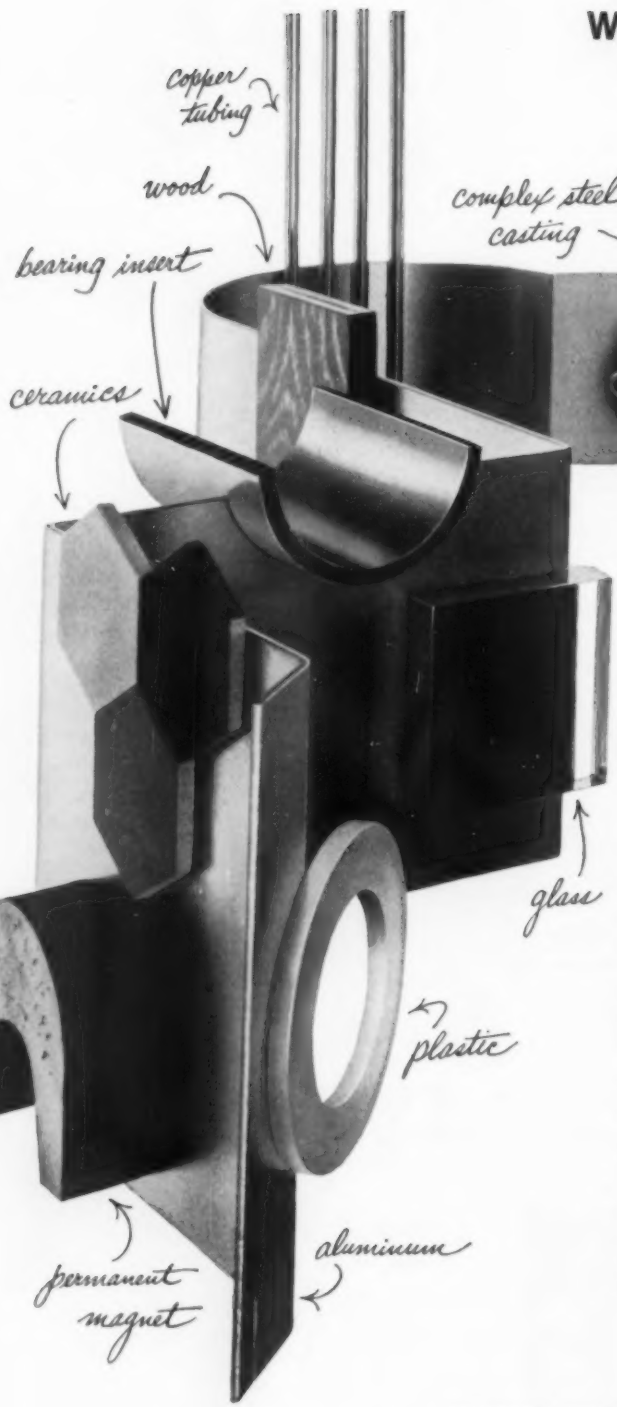
Silicone Rubber Wire Insulation withstands soldering heat without damage; matches or exceeds vital properties of insulation costing three times as much. Provides long service life at 500°F; momentarily withstands temperatures up to 5500°F. Flexible as low as —150°F, it resists moisture, ozone, nuclear radiation.

Send for technical data, "Silicones-for-Insulation." Section B1131, Silicone Products Department, Waterford, New York.



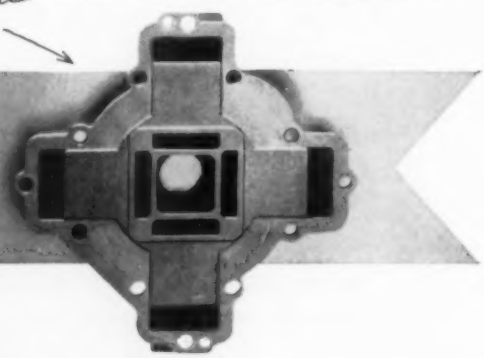
GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 473



WHAT DO YOU WANT TO BOND TO WHAT?

In metalworking, you can bond virtually any material to the same or another material with SCOTCH-WELD Brand Structural Adhesives.



Carbide wear inserts, for example, can be joined to other metals without warpage or fracturing . . . magnets can be bonded without loss of magnetic properties . . . metals, glass, ceramics—these are still other materials you can successfully bond with SCOTCH-WELD Adhesives.

By so doing, you eliminate the skill and control required in brazing and welding operations . . . you eliminate the localized stress concentrations of mechanical joining and fastening, the bimetallic corrosion between dissimilar metals. You also produce smoother contours, maintain the integrity of structural members and increase their ability to absorb joint stresses. Oftentimes, inspection and production steps can be eliminated.

The use of SCOTCH-WELD Brand Structural Adhesives in metalworking is a relatively new science. And it is one that is speeding production, cutting costs, improving product quality throughout industry. For further information, write on your company letterhead specifying area of interest to: A.C.&S. Division, 3M Company, Dept. SBHH-110, St. Paul 6, Minn.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

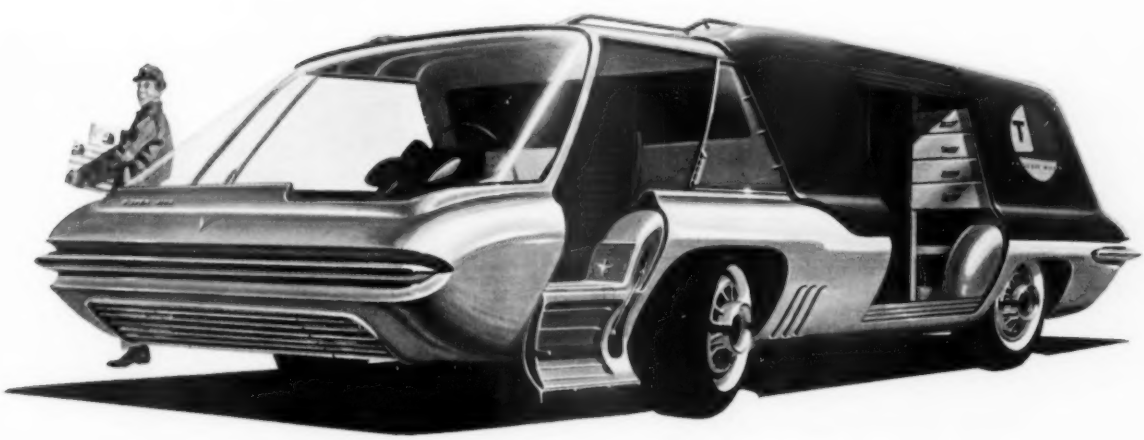
For more information, turn to Reader Service card, circle No. 415

For more information, circle No. 411

stainless steel

No other metal has the strength, beauty and versatile qualities that serve you so well today and promise so much for tomorrow.

There is nothing like stainless steel for THE AUTOMOTIVE INDUSTRY



McLouth Steel Corporation,
Detroit 17, Michigan

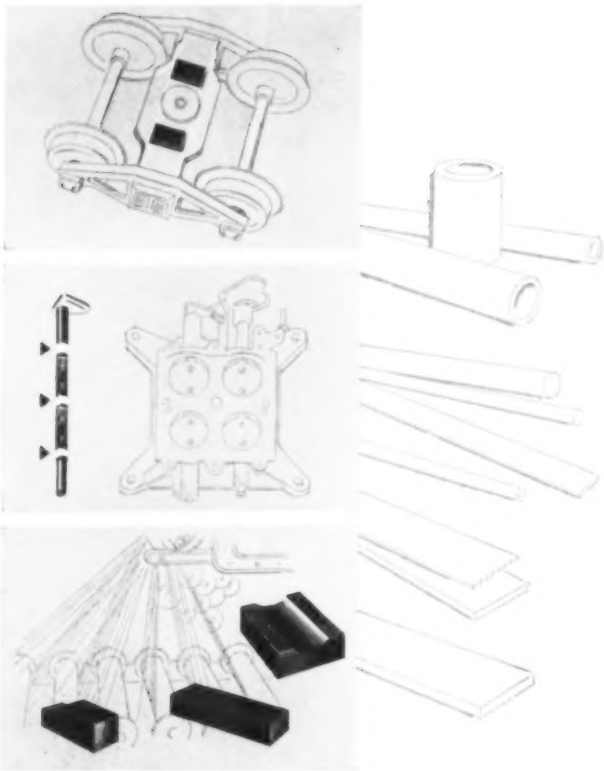
Manufacturers of high quality
Stainless and Carbon Steels

Look for the **STEELMARK** on the products you buy.

McLOUTH STAINLESS STEEL

NEW TEFLON BEARINGS

for Non-lubricated Service



Railroad truck bearings (top), carburetor bearings (center), and saddle bearings for textile machinery (bottom)—fabricated from top-quality Teflon* stock by Garlock—offer performance unmatched by any other material.

Now—new bearings of Teflon eliminate lubrication . . . resist extreme temperatures and reactive chemicals . . . drastically reduce downtime.

No finer combination of properties. Bearings of Teflon offer a lower coefficient of friction than any other solid material; they have exceptional thermal stability and are suitable for continuous service to +500°F; they are completely resistant to nearly all chemicals and solvents; they are tough, abrasion-resistant, have no moisture absorption.

Applied where safety and reliability are essential. Teflon is used as journal and thrust bearings, and on other sliding surfaces where lubricated bearings are undesirable, or incapable of operation in extreme temperatures or corrosive conditions, or where there is a possibility of lubricant failure. Teflon bearings afford unexcelled performance where slip-stick motion must be minimized . . . on reciprocating and oscillating systems where the lowest possible static friction must be attained . . . where space and weight savings are essential.

Easily fabricated from high-quality Garlock stock shapes. Teflon bearings can be simply and economically made from standard Garlock tape, bar and rod stock available through local Garlock distributor outlets. Or, if you wish, Garlock will work to your exact specifications in furnishing bearings of all tolerances and size. Whatever the case, the key to best bearing performance is through the use of Teflon stock shapes by Garlock. With years of experience in research and processing of plastics, Garlock is able to recommend and furnish *exactly* what you need, when you need it, and at the lowest possible cost.

Find out more about Teflon bearings. Consult your local Garlock representative at the nearest of the 26 Garlock sales offices and warehouses throughout the U.S. and Canada.

Or, write for Plastics Catalog AD-177, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

*DuPont Trademark

For more information, turn to Reader Service card, circle No. 378

CONVENTIONAL COPPER

Severe heat checking after 4679 hot runs

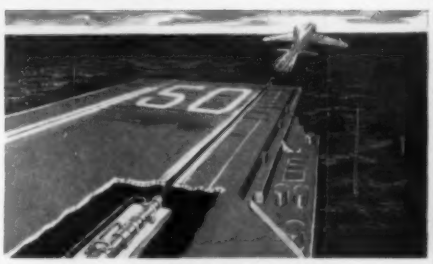
AMZIRC

No appreciable thermal effects after 6941 hot runs

AMZIRC® ZIRCONIUM-COPPER ALLOY

withstands more than 6900 hot runs of catapult powerplant at 3500 F

A critical factor in the success of the Internal Combustion Catapult Powerplant developed by Thiokol's Reaction Motors Division is reliability of the orifice plate that directs a 3500F igniter flame into the combustion chamber. When plates of conventional copper failed, Reaction Motors Division turned to AMZIRC, AMCO's new Zirconium-Copper Alloy that combines high conductivity with remarkable resistance to thermal impact. They had their answer!



Reaction Motors (Division of Thiokol Chemical Corp.) ICCP can launch a 100,000 lb. aircraft at an end speed of 125 knots in 2.25 seconds.

DESIGN REQUIREMENTS:

5000 cycles of 7 sec running at 3500F, 7 sec water cooling, 16 sec rest

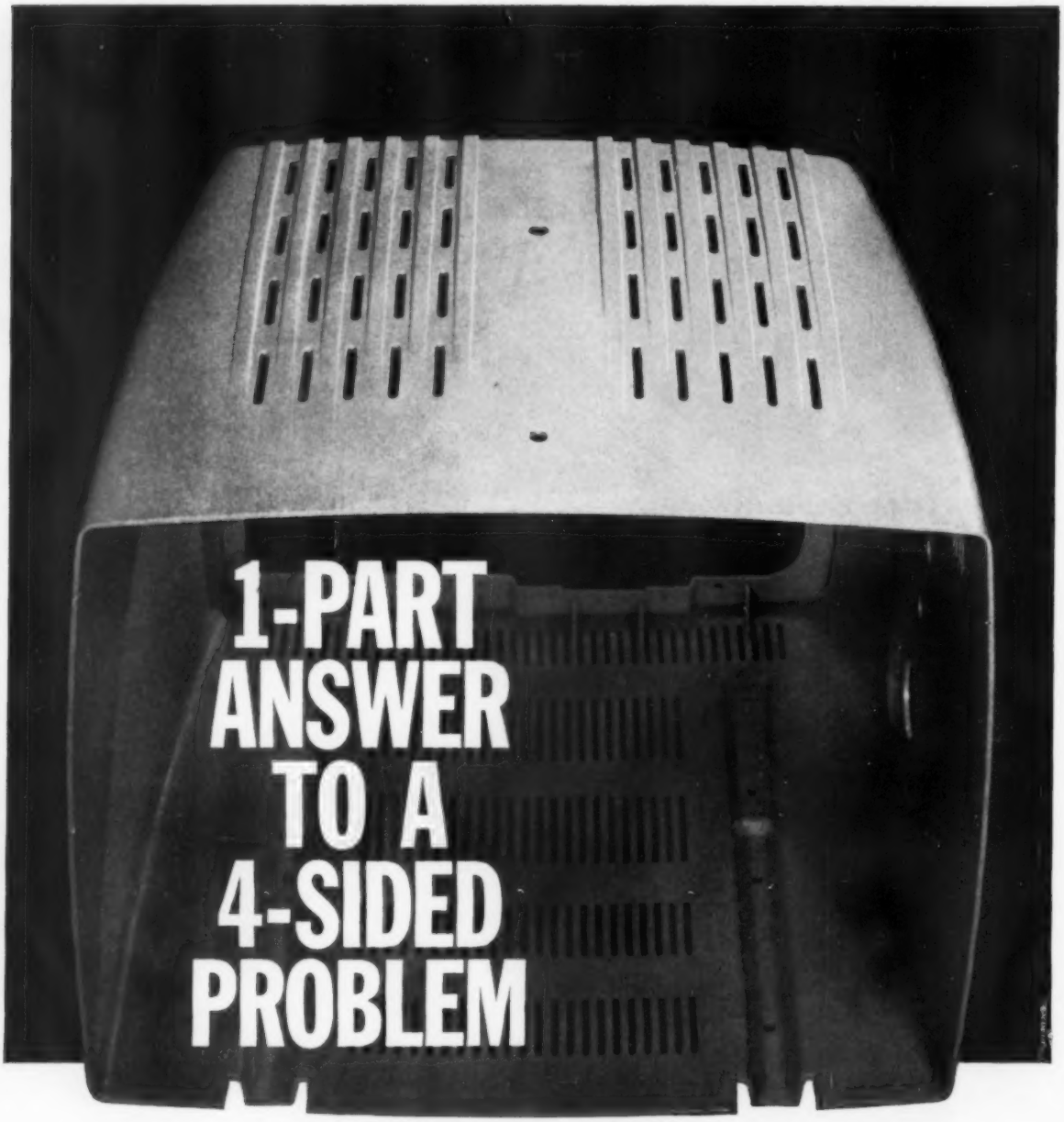
	[illegible]	[illegible]
Specifications	per Fed Spec QQ-C-576, temper soft anneal	0.1% Zr solution treated, cold-worked, aged
Total runs	4679 cycles	6941 cycles
Condition on removal	deep heat checking, orifice enlarged from 0.562" to 0.572"	no heat checking, orifice enlarged from 0.562" to 0.572"

For complete technical data and metallurgical assistance on AMZIRC contact AMCO's Technical Service Section.

AMCO a division of American Metal Climax, Inc.

1270 Avenue of the Americas, Rockefeller Center, New York 20, N. Y.

AMZIRC is also known as N-4 Alloy



Just one shot on an injection press, and out comes this complicated 17-inch television cabinet weighing 1970 grams! Openings and grilles on all four sides required a mold opening in four directions. General American's ability to mold a cabinet like this means expanded opportunities in the use of plastics in all industries—since skilled die-makers working with production engineering experts assure the successful execution of the most demanding designs.

Have you thought that perhaps your part or product could be produced more efficiently and economically in plastics? With greater eye-appeal? Techniques developed by years of molding experience, together with the unequalled facilities at General American provide a source upon which you can call—and depend.

In plastics, as in so many other areas, *it pays to plan with General American.*

Plastics Division

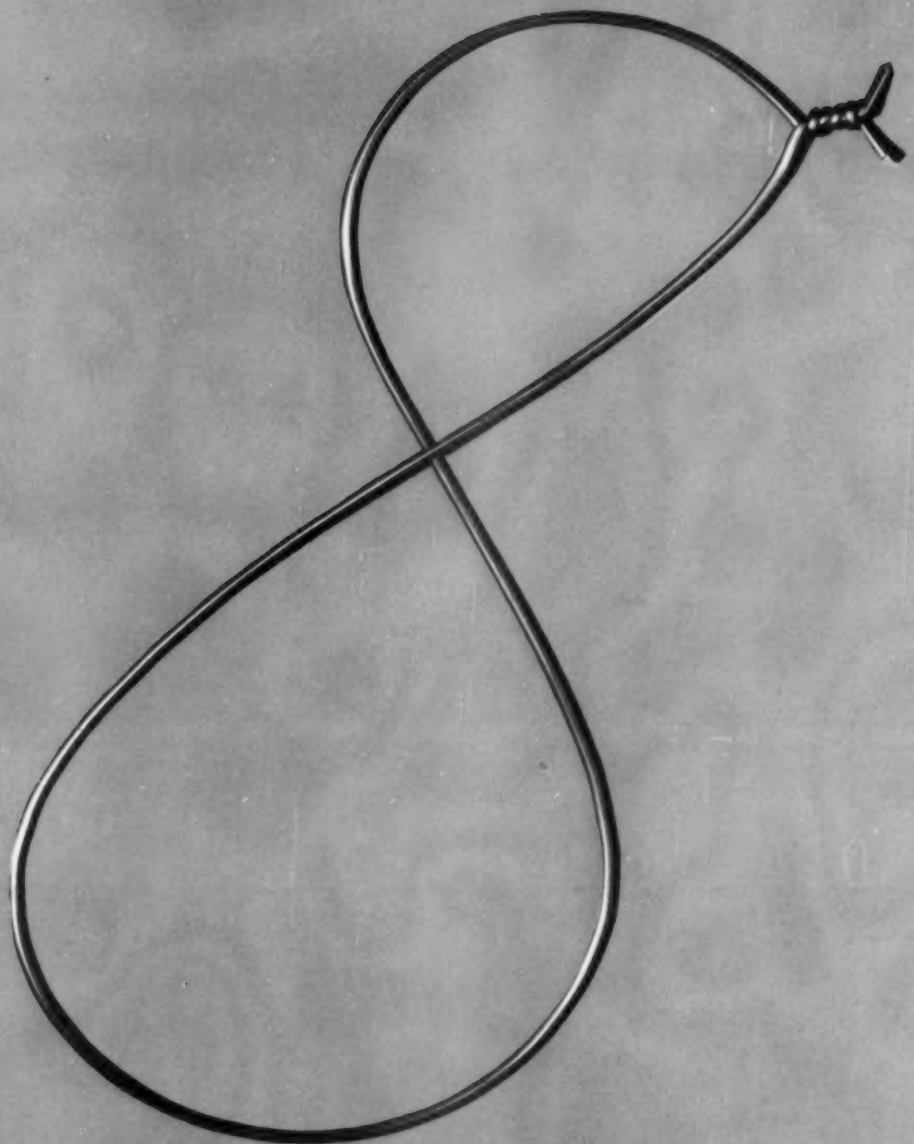
GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street · Chicago 3, Illinois

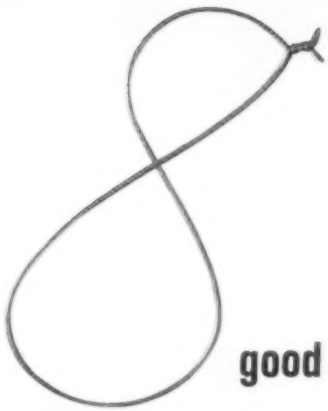
Offices in principal cities

For more information, turn to Reader Service card, circle No. 380

For more information, circle No. 467



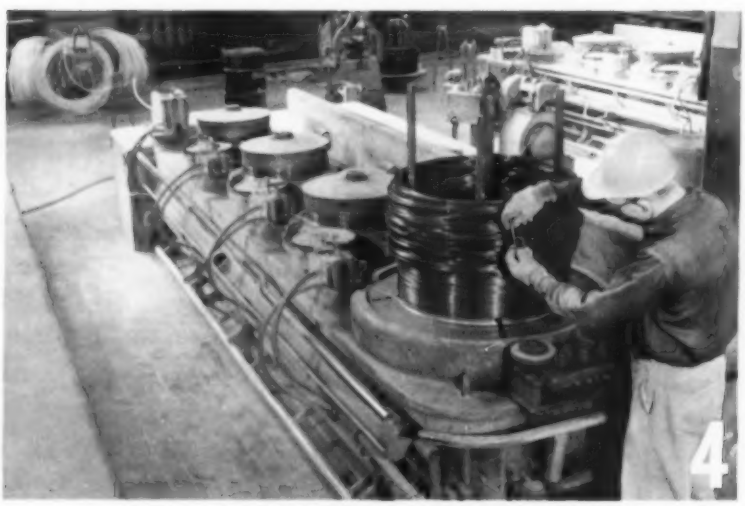
good reasons
why it pays to specify
American Steel & Wire
for all of your
stainless steel wire needs



8 good reasons why it pays to specify American Steel

By using modern welding techniques, we can turn out continuous coil weights as heavy as 500 pounds to suit your particular needs. Heavier coil weights reduce down time on your machines, speed handling of material.

The latest in controlled annealing methods enable us to produce uniform properties in stainless wire that assure consistent performance on your equipment and in your product.



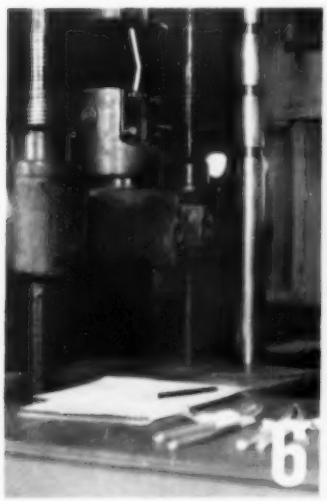
To insure the gage of your stainless is consistent from end to end, it's checked constantly during the continuous drawing process. ASW's wide range of modern, precision drawing machines can turn out everything you need in type, size and finish.

After drawing, the wire is again inspected to make certain that the gage and finish are exactly as specified.

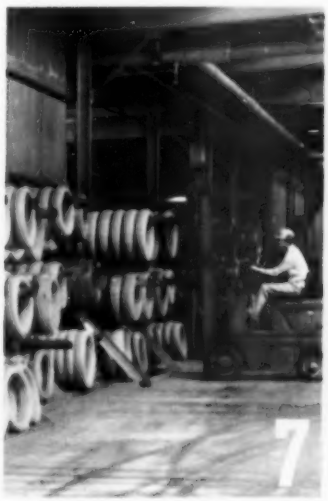
This mark tells you a product is made of modern, dependable Steel.

& Wire for all of your stainless steel wire needs

Up-to-date salt and acid bath techniques and equipment guarantee the smooth, clean wire surface so important to the finished quality of your product. After cleaning, coatings such as this electrolytic copper coating are often applied to make your job of fabrication easier.



During processing and at finished size, our stainless wire is tested for tensile strength and other properties to make sure it meets specifications. Such tight control insures quality.



To insure supply and fast delivery, we stock 300 to 400 tons of cold heading stainless wire in addition to a heavy tonnage of other stainless steel wire items at all times.

8 **Our stainless steel wire service is second to none.** In addition to our regular salesmen, we have special Stainless Steel representatives in your area who have both engineering and mill backgrounds. They know metals, they know production. Their assistance can be invaluable to you in solving the really tough ones. Call your nearest ASW Sales Office today. If you like, we'll have a man out to see you at your convenience. Or if you prefer, write American Steel & Wire, Dept. 0384, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

American Steel & Wire
Division of
United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, New York

CELANESE
POLYMER COMPANY

Offers a Complete Service-in-Depth for Users of Plastic Materials

Celanese Polymer Company offers manufacturers, molders and product designers a comprehensive plastics service that includes assistance in application and design, plastics selection and product testing . . . laboratory and field service . . . and prompt deliveries from strategically located warehouse facilities.

Celanese Polymer Company is a Division of Celanese Corporation of America.

High, Medium and Low Density
POLYETHYLENE

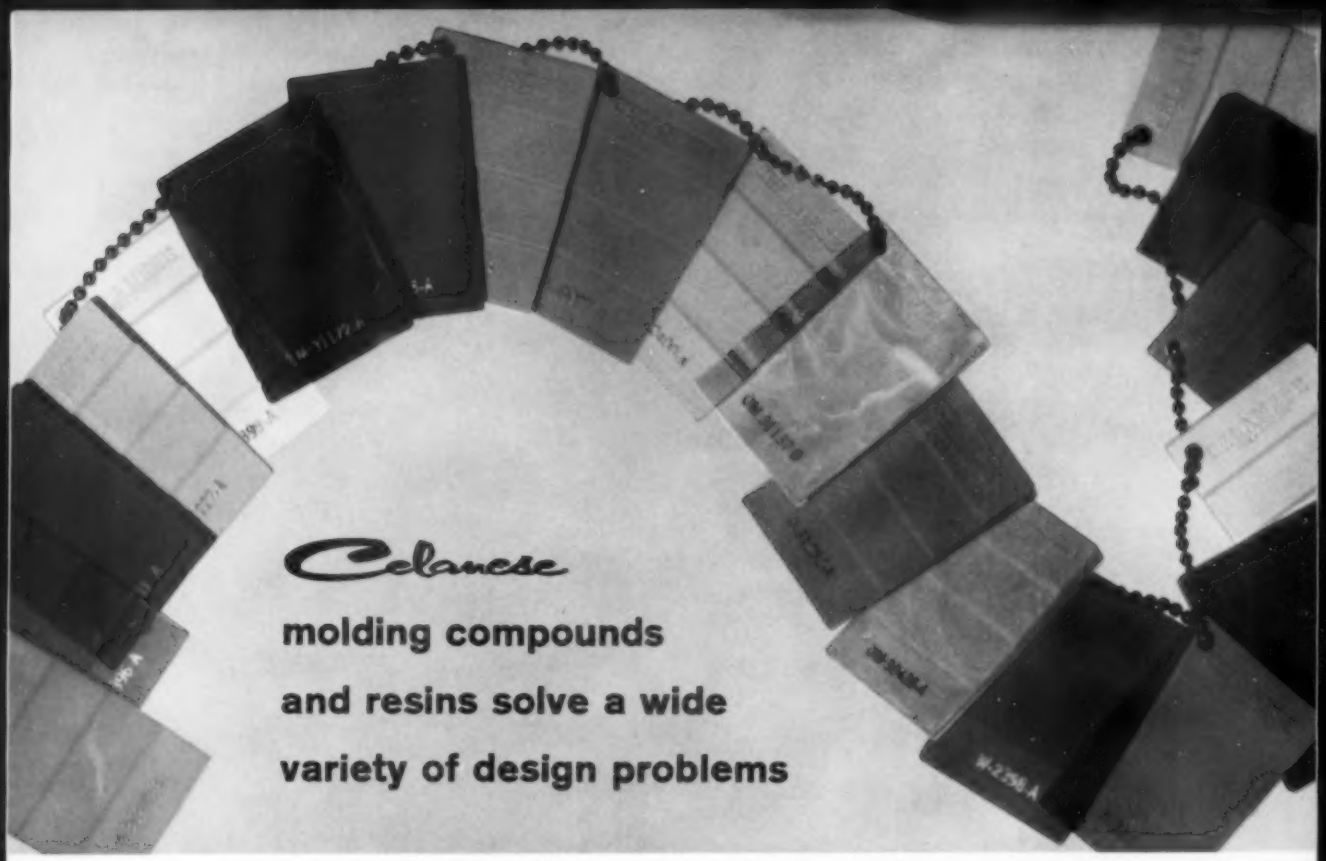
CELLULOSE PROPIONATE

CELLULOSE ACETATE

POLYESTER RESINS

Acetate, Propionate and Triacetate
CELLULOSE FLAKE

★ ★ ★
TECHNICAL SERVICE



Celanese

molding compounds and resins solve a wide variety of design problems

FORTIFLEX . . . A Complete Range of Polyethylenes

Resins ranging from high to low density. There are four basic Fortiflex types: Series A, B, C, and D. Fortiflex A and B available in natural or scientifically color-matched to your specifications. Fortiflex C and D available in natural only. Applications: housewares, appliances, automotive and electrical parts, wire insulation, pipe, toys, containers, paper coating, film and sheet.

FORTICEL . . . Cellulose Propionate

Outstanding among thermoplastics for its excellent balance of properties, Forticel meets the demands of a number of automotive and appliance applications. Forticel has excellent dimensional stability, toughness, surface permanence and moldability, and is free of objectionable odor. Applications: automotive steering wheels and decorative trim, appliance and telephone housings, brush backs, dials, knobs and blow molded products.

ACETATE . . . Cellulose Acetate

Rugged, versatile, economical, Celanese Acetate is unequalled for its combination of toughness, clarity and price. It is available in a wide range of formulations and flows—in a limitless variety of scientifically matched colors. Applications: shoe heels, appliance housings, jewelry, tool handles, toys, sun glass frames, brush backs, houseware items and blow molded products.

POLYESTER RESINS

Here are the properties that speed production, cut down rejects. Celanese Polyester Resins offer fast cure, low drainage, better wet-out in hand lay-up. They are unequalled for saving time and labor on critical large area moldings. And they are outstanding for formulating and molding pre-mix and matched die parts. Applications: Boats, refrigerator doors, truck bodies, cooling tower grids, automotive and appliance parts, electronic housings, and decorative items.

CELLULOSIC FLAKES

Celanese offers cellulose acetate, cellulose triacetate and cellulose propionate flake in a variety of grades to basic industries such as plastics, sheet, film, fibers, protective coatings and adhesives. Specific applications include lacquer for paper, wire, and flashbulb coatings; film and sheeting for photography, graphic arts, and transparent packaging; molding powder for extrusion and injection molding of tool handles, tubing, and toys; and binders for color concentrates.

CELANESE TECHNICAL SERVICE

Celanese has the engineering staff to help you get the most out of plastic materials at any stage from design to finished product. This service includes: design consultation, assistance with mold design, material selection, equipment and its adaptation, pilot molding supervision and product testing.

The Celanese Technical Service Laboratory is one of the finest of its type. It is complete with actual production equipment, color matching departments, and analytical and physical testing laboratories. For the right answers to problems of plastic application, or technical information on specific plastic materials, write: Celanese Polymer Company, Dept. GK-11, 744 Broad Street, Newark 2, New Jersey. Celanese® Fortiflex® Forticel®

Celanese Polymer Company is a Division of Celanese Corporation of America.
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Ave., New York 16.

Celanese
PLASTICS

TAKES OFF ITS HAT TO NOBODY!

Carriage, lag and machine bolts.
All sizes. Quick delivery from stock.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export distributors: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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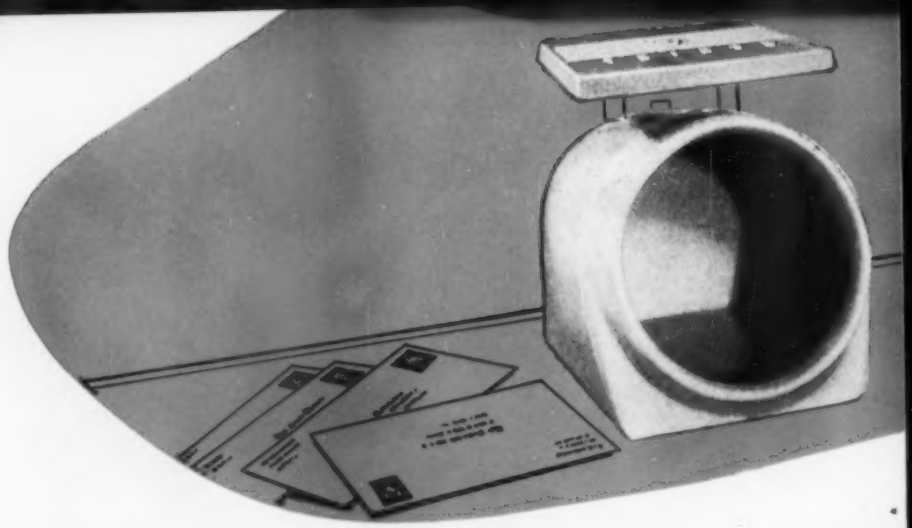
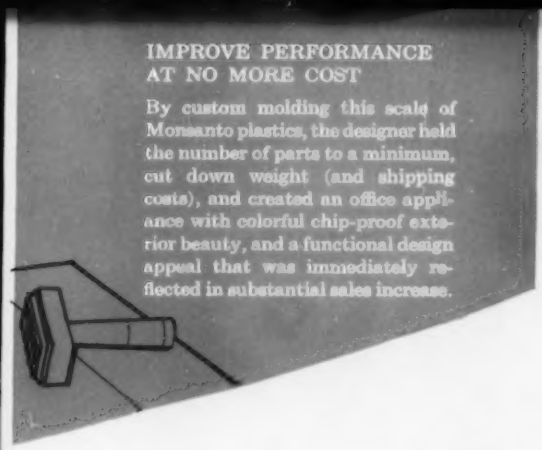


MOLDED PLASTICS MEET BOTH

CUT COSTS AND IMPROVE PERFORMANCE

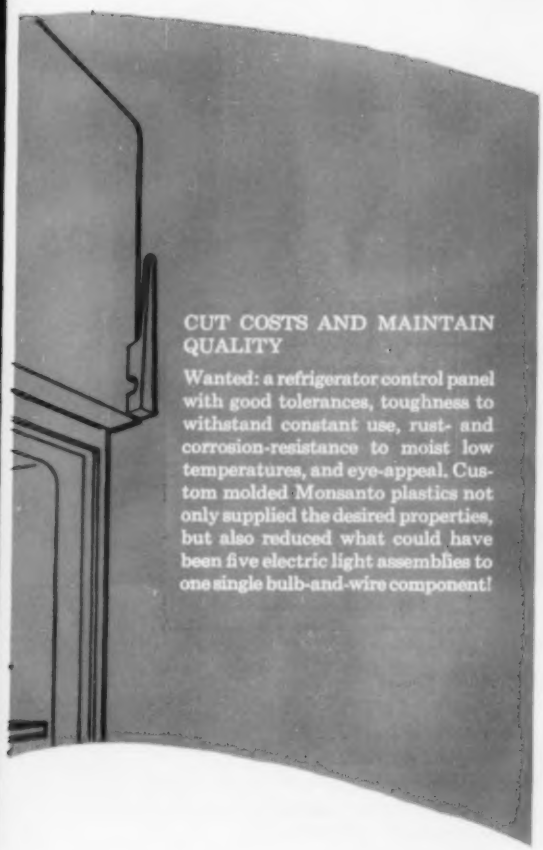
Designing this vent to be molded of high impact polystyrene, eliminated the cost of painting. A metal pinion, included in the one-piece molding, secured the vent to the conditioner housing, easing assembly. The unit is also lighter in weight, and its rust- and tarnish-proof surface is easier to clean.



IMPROVE PERFORMANCE AT NO MORE COST

By custom molding this scale of Monsanto plastics, the designer held the number of parts to a minimum, cut down weight (and shipping costs), and created an office appliance with colorful chip-proof exterior beauty, and a functional design appeal that was immediately reflected in substantial sales increase.

PERFORMANCE AND COST CONSIDERATIONS



CUT COSTS AND MAINTAIN QUALITY

Wanted: a refrigerator control panel with good tolerances, toughness to withstand constant use, rust- and corrosion-resistance to moist low temperatures, and eye-appeal. Custom molded Monsanto plastics not only supplied the desired properties, but also reduced what could have been five electric light assemblies to one single bulb-and-wire component!

Why is it that molded plastic can offer wide design latitude—the welcome freedom to develop product ideas with eye and sales appeal without sacrificing performance for price?

One reason, as demonstrated by the examples opposite, is the unique efficiencies and economies inherent in custom molded plastics. Simplified production, for instance. Multiple parts molded in one piece. The elimination of finishing steps—buffing, grinding, tapping, cementing, machining. The unlimited color choice—molded in, not painted on. The close tolerances held even in high speed mass production. The lighter weight for easier handling, lower shipping cost.

There is a wealth of plastics molding compounds with constantly improved combinations of properties, from which to select a material that will match both cost and quality end-product demands.

And last, there's the custom molder. Well known as a mass producer, he is much more. He knows the design capabilities of the many plastics. He can recommend the best formulation, engineer the mold to capitalize on the advantages of molding techniques. He can turn out plastics parts with unusually consistent quality, at rates to meet the tightest schedules and budgets.

As a handy guide for designers, Monsanto has developed a "Plastics Properties Calculator." Send coupon below for yours.

For more information, circle No. 416

Monsanto supplies custom molders with molding formulations of Monsanto Polyethylene, Lustrex® Styrene, and Opalon® Vinyl, specially developed and constantly perfected to meet the widening range of design requirements.

Monsanto

MONSANTO INITIATOR IN **PLASTICS**

MONSANTO CHEMICAL COMPANY
Plastics Division—Room 722
Springfield 2, Massachusetts
Please send me a free "Plastics Properties Calculator"

Name_____

Title_____

Firm_____

Address_____

City_____ Zone____ State____

CYCOLAC®

THE BORG-WARNER PLASTIC THAT'S TOUGH, HARD, AND RIGID

Refrigerated car door liners were always made of metal and wood . . . until Landis Industrial Company looked into CYCOLAC. This giant shell made for Pacific Fruit Express by Landis had to withstand impact at sub-zero temperatures and provide excellent moisture resistance. Equally important was weight reduction without sacrifice of strength or durability. CYCOLAC, the tough, hard, rigid ABS plastic from Borg-Warner, delivered the goods on every count! Now, air-tight doors combining CYCOLAC for the inner liner and Dylite® insulating foam made by Koppers Company, Inc., protect frozen food shipments—at a substantial saving. CYCOLAC may be the material you need. Do as Landis did—investigate this remarkable plastic now.

MARBON CHEMICAL DIVISION **BORG-WARNER**
WASHINGTON WEST VIRGINIA

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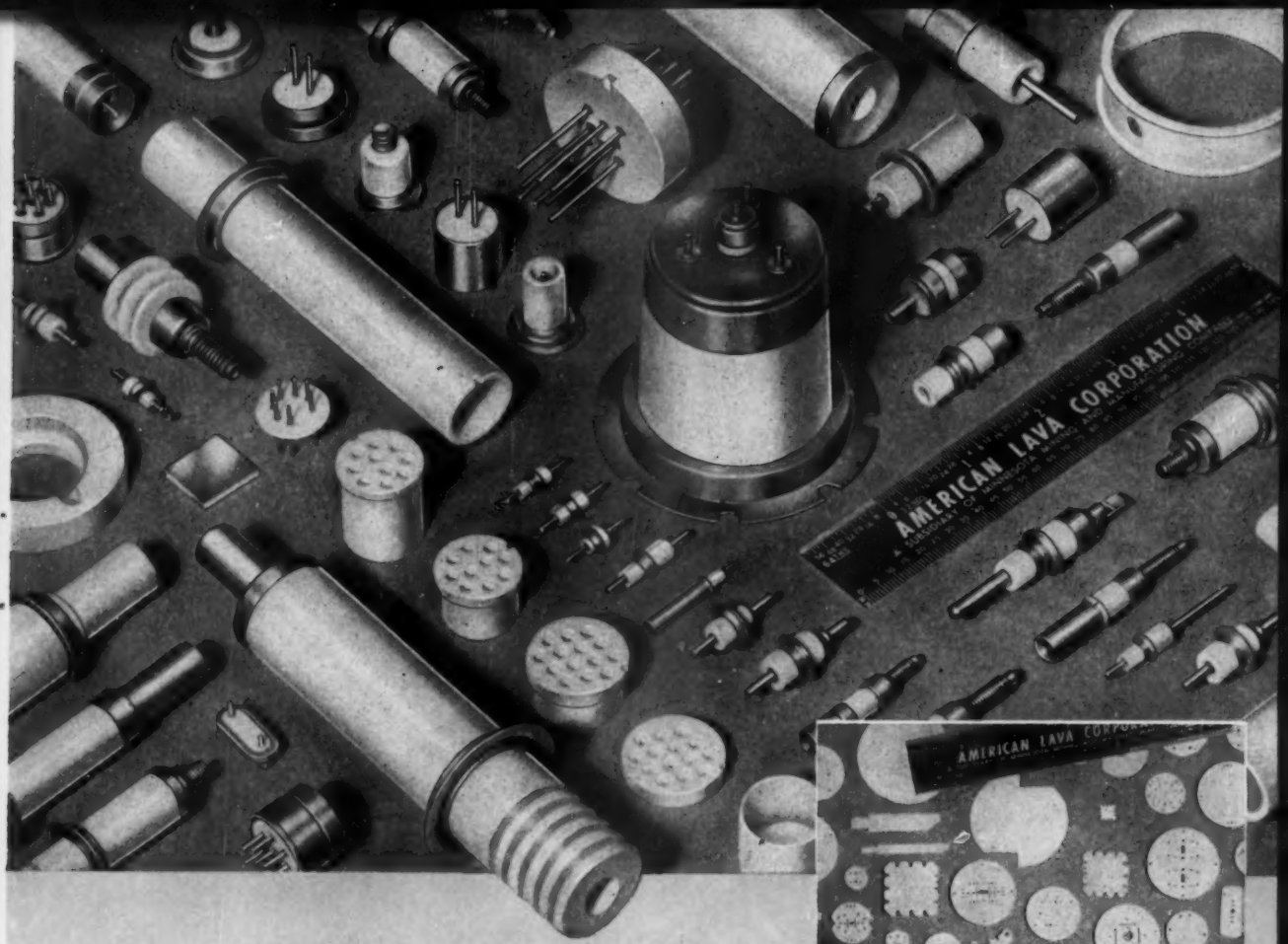


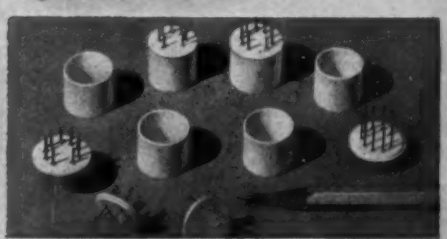
RELIABILITY

IS AN OUTSTANDING CHARACTERISTIC OF ALSIMAG® CERAMICS

AlSiMag Ceramics offer exceptional resistance to heat and erosion. They have marked electrical and physical stability at elevated temperatures and in varying environments. Chemically inert. Good strength. Can be accurately fabricated in micro-miniatures.

AlSiMag Ceramics include many special purpose ceramics, some especially adapted to hermetic sealing. Widest choice of materials, more than half a century of specialized experience. Send blue print and operating conditions.

AlSiMag pioneered micro-miniature ceramics . . . some as thin as 0.005". Relatively high strength, superior performance at high temperatures, high frequencies. Excellent record for withstanding fatigue, heat, shock, vibration.



The AlSiMag Ceramics in these multiple pin headers may be safely used up to 2800°F. The metal components are the limiting factors.

These tantalum pins with nickel braze alloy operate around 1000° F. All materials are rugged. Strong hermetic seal. Low vapor pressure. High temperature bake-out is practical.

A Subsidiary of Minnesota Mining and Manufacturing Company

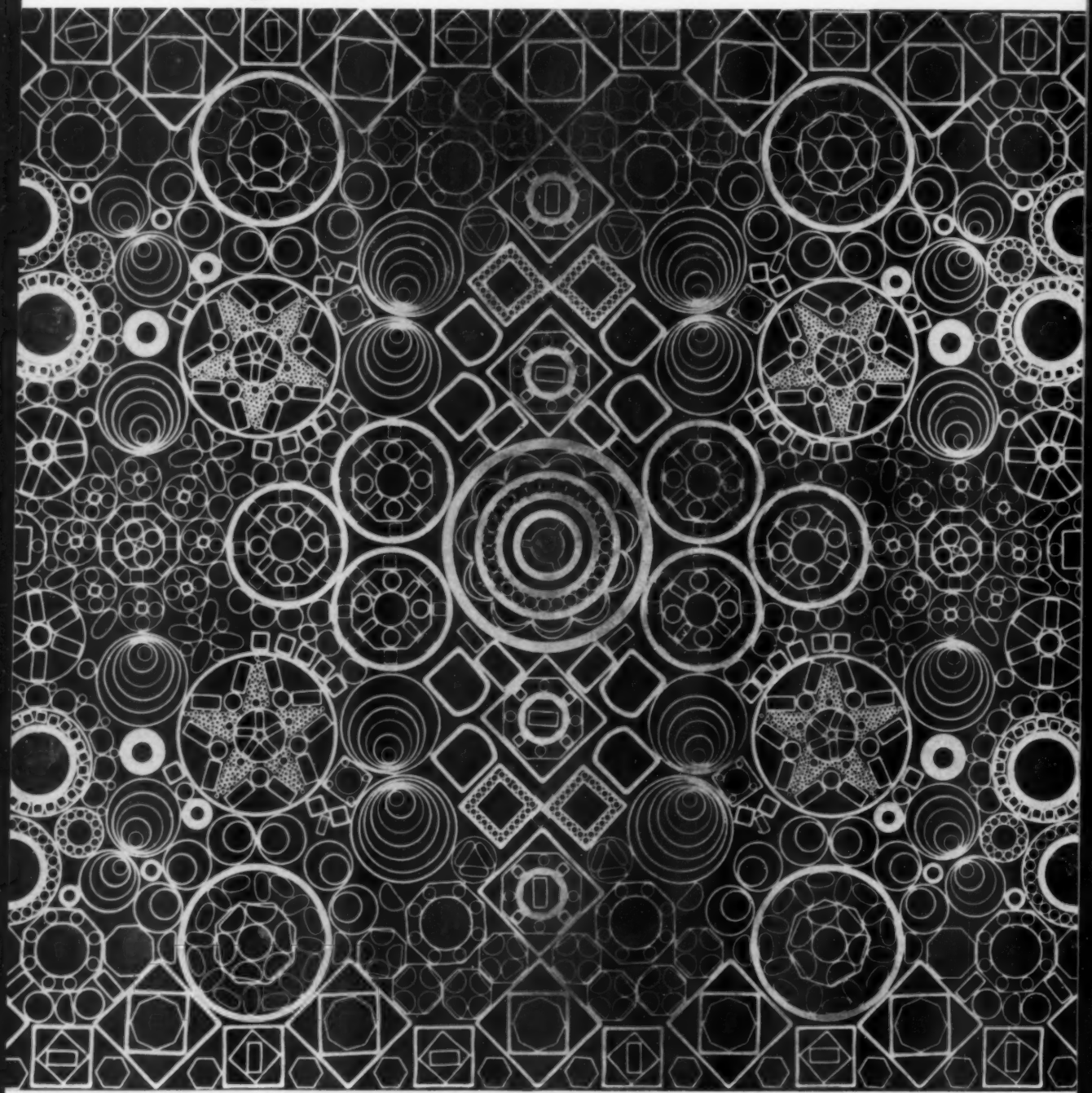
AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.
58TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston: Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, O. • Dallas, Texas • Los Angeles, Cal. New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash. **All other export:** Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

For more information, turn to Reader Service card, circle No. 325

This mark tells you a product is made of modern, dependable Steel.



Seamless Steel Tubing comes in almost every shape and size, that is, if it's **USS National Seamless Mechanical Tubing.**

USS and National are registered trademarks

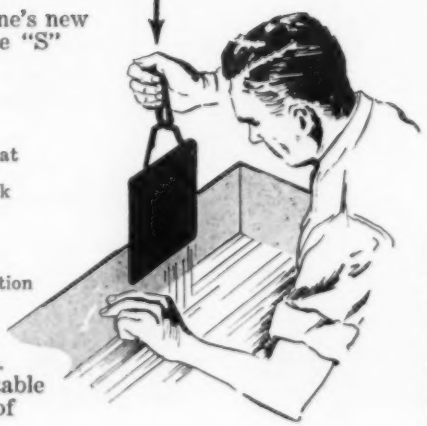
National Tube
Division of
United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors; United States Steel Supply Division; United States Steel Export Company, New York

For more information, turn to Reader Service card, circle No. 466

red smut?

not on this blackened steel



No red smut forms on any iron and steel parts when Enthone's new Ebonol Additive "S" is used in blackening baths. Additive "S" effectively holds in suspension dissolved iron and copper, preventing deposition of red smut on the work.

ADVANTAGES OF ADDITIVE "S" ARE:

- Eliminates red smut
- Produces deeper black
- Shortens blackening time
- Permits lower blackening temperature
- Increases production
- Improves ability of present baths to coat hard-to-blacken alloys
- Maintains corrosion resistance of black oxide coating
- Permits blackening of copper-brazed steel parts
- Costs less than other methods of controlling iron and copper contamination

Ebonol Additive "S" is used in all steel blackening baths which contain oxidizing agents and caustic soda and produce a coating in the 285°-305°F temperature range. It is a concentrated solution of blended complexing agents stable to oxidizing agents, high alkalinity and high temperatures of blackening baths.

Visual observation of the work is the only control required. At the first sign of red smut, add 1-2 ounces of Ebonol Additive "S" to each gallon of solution.

For complete information, write to Enthone, Inc., 442 Elm Street, New Haven 8, Conn.

ASARCO

ANOTHER PRODUCT OF Enthonics RESEARCH

ENTHONE

A Subsidiary of American Smelting and Refining Company

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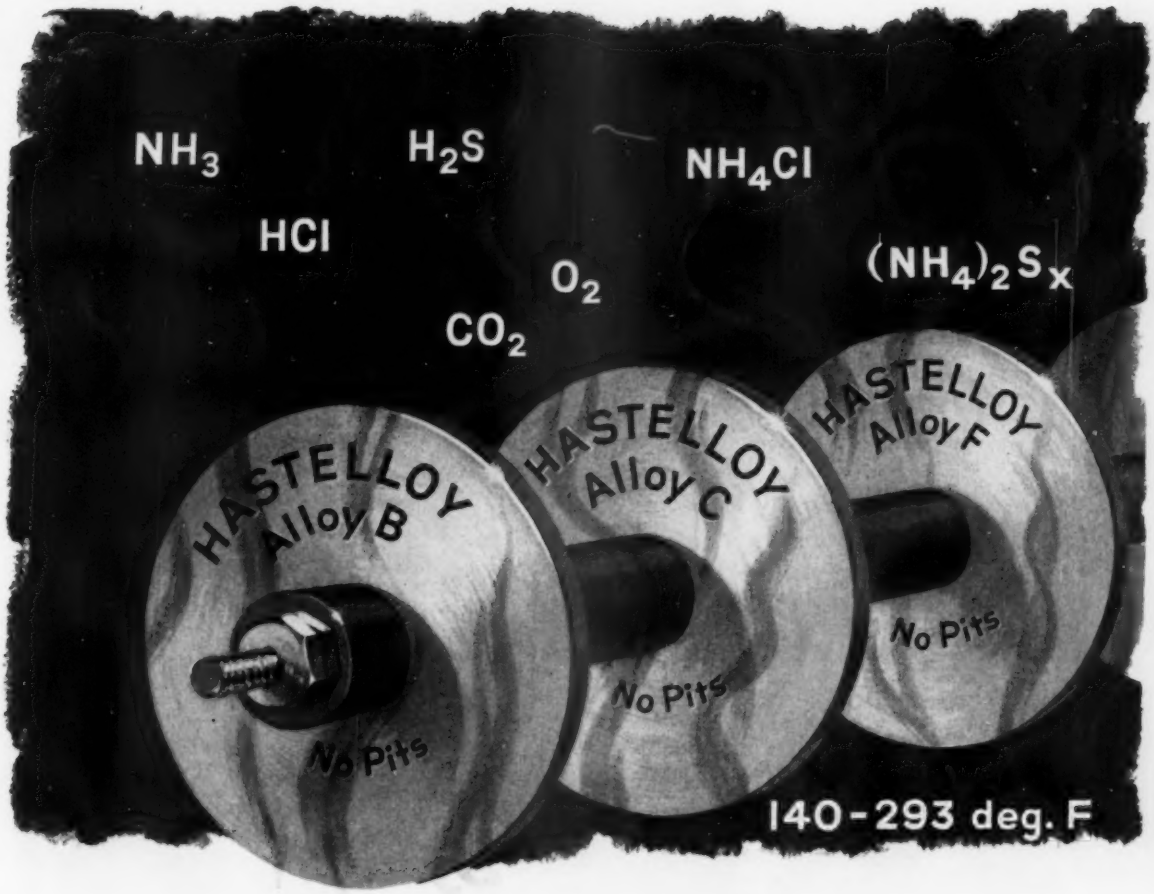

Pitting Corrosion a Problem?

...Test **HAYNES** Alloys

No pitting from chlorides . . . and less than 1 mil per year penetration . . . on HASTELLOY alloys B, C, and F! These were the results of on-stream tests at six locations in the low-temperature zone of a hydrocarbon bubble tower.

Yet ten other alloys tested showed extensive pitting . . . and corrosion rates up to 15 mils.

Send for test samples

Have you perplexing corrosion problems in your processing equipment? To help you solve them, we have been testing, developing, and perfecting corrosion-resistant alloys for thirty years. We'll gladly send you free samples of HAYNES alloys for you to test yourself.

To be sure you receive the alloys most suited to your needs, please send us as much data as possible about the corrosion problem involved. Ask for a copy of our booklet on HASTELLOY alloys. Write us at 270 Park Avenue, New York 17, N. Y.

HAYNES ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

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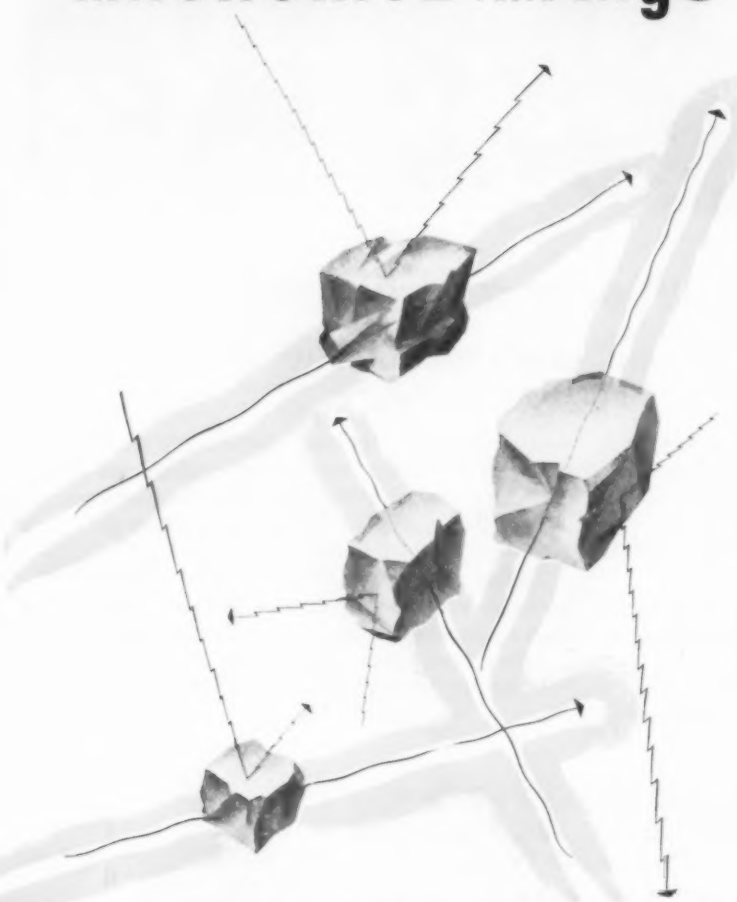
Outstanding
by Nature . . .
Improved
by NORTON . . .

MAGNORITE* Fused MgO



The inherent capabilities of magnesium oxide are vastly improved by Norton Company processing. Selected grades of magnesia are transformed in our electric furnaces into high purity MAGNORITE fused magnesium oxide — a crystalline material with extremely useful chemical and physical properties.

Norton MAGNORITE fused MgO is available in a complete range of grades, granular sizes and in a variety of fired shapes. For example, one top grade offers the following properties: *High Electrical Resistivity* (10^8 *ohm-cm at 900°C*). *High Melting Point* (*2800°C*). *Good Thermal Conductivity* (*0.023 Cal* • Sec^{-1} • Cm^{-2} • $°C^{-1}$ *at 700°C*). *High Chemical Purity* (*99.5% MgO*). *High Chemical Stability with Most Metals. Readily Crushable. Easily Packed to High Densities.*

MAGNORITE fused MgO is the world's most widely used brand . . . for containing special metal melts and keeping them free from impurities . . . as insulation for thermocouples and sheathed electrical heating elements . . . as an ingredient of ceramic electronic components. Infrared transmission through single crystals is excellent. And these are just a *few* of the uses for this versatile material.

Investigate *all* of the advantages of MAGNORITE fused MgO and how it can benefit your product or process. Write regarding *your* specific application and for complete details. NORTON COMPANY, 350 New Bond St., Worcester 6, Massachusetts.

*Trade-Mark Reg. U.S. Pat. Off.

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REFRACTORIES
Engineered . . . Rx . . . Prescribed

75 years of . . . Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — BEHR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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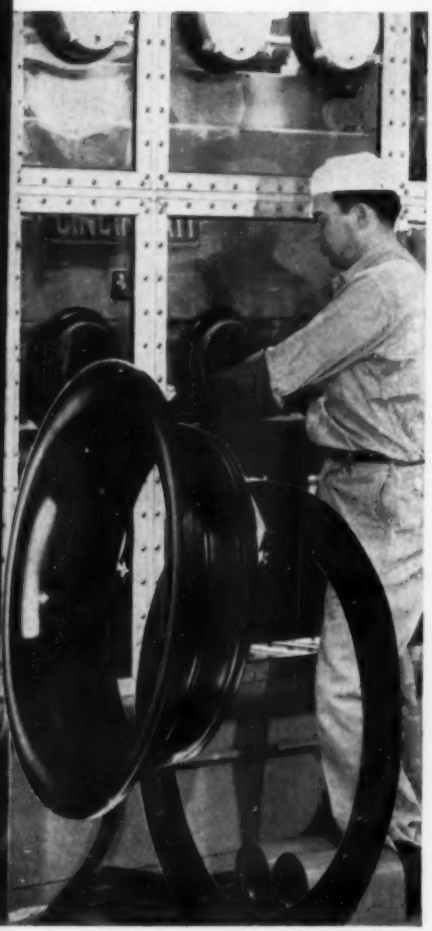
For more information, circle No. 363 ➤

Product-Design
BRIEFS
from Durez



ARGONNE NATIONAL LABORATORY

PHENOLIC PORTHOLES? WHAT NEXT!

Atomic engineers have found a good way to seal those big gloves that handle plutonium and its deadly cousins in inert-atmosphere chambers.

The port you see here does this critical job well. It is compression molded of a Durez medium-impact phenolic. It doesn't leak. It also resists shock, corrosion and heat. Its smooth surface won't snag the rubber glove. And it is economical: metal inserts can be molded right in. Except for polishing off flash, it's all finished when it comes off the press.

Have *you* looked into atom-age phenolics lately? They're better, more versatile than ever. To see what they can do for you, check the coupon for our Bulletin D400. It lists properties, uses, advantages of many interesting Durez compounds.

PUT THE BRAKES ON HEAT

No, this isn't a magic powder you sprinkle on a product to make it resist heat. It is a material—Durez phenolic resin—that's used in scores of products as a *bonding agent* to impart controlled degrees of heat resistance.

Brake linings are just one example. Some others: electronic resistor coatings, shell molds and cores for foundry use and automotive generator brushes.

For heat resistance at low cost, you just can't beat phenolic resin. If you have such an application, write us the details and we'll gladly try to help you as we have helped many others.

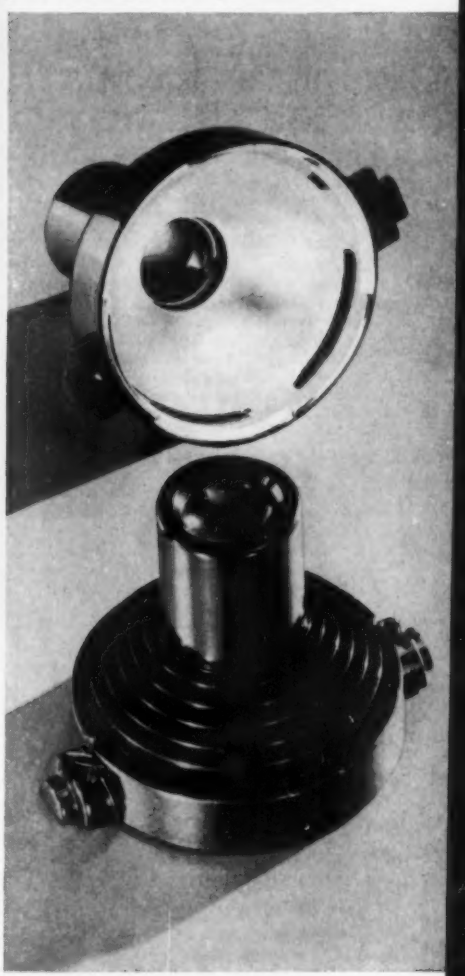
BRIGHT IDEA: PLASTIC-METAL MIRROR

Metallized phenolic saves a costly production step in this housing for a microscope lamp.

In place of a custom-made reflector, the molded phenolic housing has an aluminum mirror deposited right on it by vacuum metallizing.

The Durez compound chosen for this part has the right surface for metallizing, and incorporates high impact strength, low thermal conductivity.

You'll find many helpful ideas like this in *Durez Plastics News*, special bulletin mailed periodically to thousands of product-design men. A check mark on the coupon will bring *News* to you faithfully.



For more information on Durez materials mentioned above, check here:
☐ Phenolic molding compounds—descriptive Bulletin D400 ☐ Phenolic resins—illustrated bulletin describing uses ☐ *Durez Plastics News*—mailed periodically
Clip and mail to us with your name, title, company address. (*When requesting samples, please use business letterhead.*)

DUREZ PLASTICS DIVISION
1411 WALCK ROAD, NORTH TONAWANDA, N. Y.
HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Copper Alloy Bulletin

BRIDGEPORT BRASS COMPANY

new BRIDGEPORT NIRONZE® 635 gives 90,000 psi yield strength

90,000 psi Yield Strength Obtained with New Age-Hardenable Copper-Nickel-Silicon Alloy

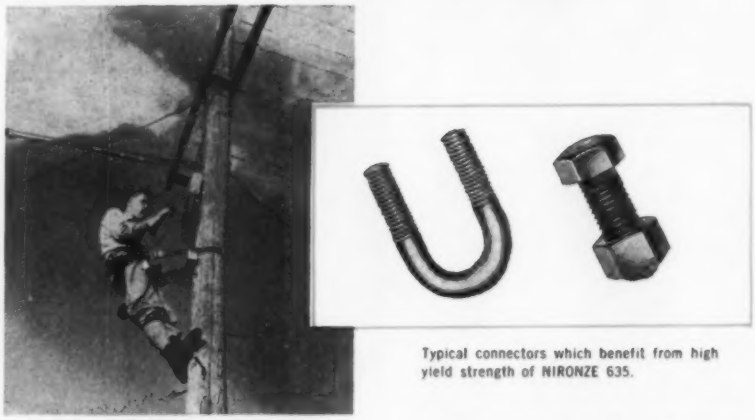
Bridgeport Nironze 635, an age-hardenable copper-nickel-silicon alloy, combines excellent cold-working properties with high tensile and very high yield strengths, good electrical conductivity, excellent general and stress-corrosion resistance. Supplied in the solution-treated and drawn condition, Nironze 635 offers exceptional cold-working properties. A low-temperature heat treatment, following additional cold-work age, hardens this alloy to produce tensile strengths of 100,000 psi, yield strengths of 85,000 psi and improved electrical conductivity of a minimum of 35% IACS.

Easily Cold-Formed ... Machined

The excellent cold-working properties of Nironze 635 in the *solution-treated and drawn* condition allow such severe cold work as upsetting, cold-heading, roll-threading, bending, forming or similar operations to be carried out with ease. Heat treatment following this cold-work age-hardens this alloy to produce maximum tensile and yield strengths.

Nironze 635 in the *solution-treated-drawn-aged* condition has a machinability about 30% of free-cutting brass rod, thereby making it possible to carry out such conventional machining operations as sawing, grinding, turning, milling or similar operations.

Maximum cold-work may be performed on Nironze 635 in the *solution-treated* or soft condition. In order to obtain highest possible physical properties, this alloy must be cold-worked from 50-80% before aging.



Typical connectors which benefit from high yield strength of NIRONZE 635.

Proved by Performance in These Applications

Cold-headed bolts and fasteners used in pole line hardware, switch gear, wire connectors, neon signs, railway equipment, exposed electrical parts and structural supports, marine hardware and fittings can all use Nironze 635 to advantage. The new alloy's unique combination of high yield and tensile strengths, good conductivity and high corrosion resistance provides design and production advantages never before offered by a silicon bronze.

Test a Sample Now

Nironze 635 has been thoroughly evaluated in the laboratory and in the field to insure the high quality and top performance common to all Bridgeport alloys. To get your test samples and full technical information, call your nearest Bridgeport Sales Office. Or write us direct. Dept. 3511

Nironze 635 is presently available as rod or wire, supplied in the solution-treated, solution-treated and drawn, and solution-treated, drawn and aged.

NIRONZE PHYSICAL PROPERTIES

Density	0.320 lb/in.³
Color Red	similar to copper
Thermal Expansion	8.9 x 10–⁶/°F
Melting Point	1990°F
Nominal Composition:	
Copper	97.5%
Nickel	1.9%
Silicon	0.6%
Total	100.0%
Electrical Conductivity, % IACS	
Cold-drawn and aged	30%
Cold-drawn	15%

MECHANICAL PROPERTIES
(Nominal)

Form	Condition	Tensile Strength psi	Yield Strength psi	Elongation % (4D)	Contraction of Area %	Rockwell B Hardness	0/0 IACS
Rod and Wire	Solution-Treated	40,000	12,000	50	90	7	24
	Solution-Treated, Aged	88,000	70,000	12	20	86	43
	S.T. Drawn 50%	65,000	62,000	18	87	67	32
	S.T. Drawn 50%, Aged	100,000	90,000	12	25	95	42
	S.T. Drawn 80%	70,000	65,000	15	85	73	32
	S.T. Drawn 80%, Aged	103,000	97,000	17	62	96	39

COMPARATIVE RATINGS OF NIRONZE 635 vs STANDARD SILICON BRONZES

	Physical Properties			Fabrication Properties			Mechanical Properties		
	Electrical Conductivity (Annealed) % IACS	Melting Point Liquidus °F	Density lb/in.³	Cold Workability	Machinability Rating %	Annealing Temp. °F	Tensile Strength psi	Yield Strength psi	Rockwell B Hardness
NIRONZE 635	*35	1990	0.320	Excellent	*30	**850-900	100,000	85,000	88
High Silicon Bronze (A)	7	1850	0.308	Excellent	30	900-1300	108,000	60,000	95
Low Silicon Bronze (B)	9	1940	0.316	Excellent	30	900-1250	90,000	67,000	80

*The term "Nironze" is a registered trade-mark of the Bridgeport Brass Company

*Drawn and aged **Aging temperature

BRIDGEPORT BRASS COMPANY
Bridgeport 2, Connecticut • Sales Offices in Principal Cities
Specialists in Metals from Aluminum to Zirconium

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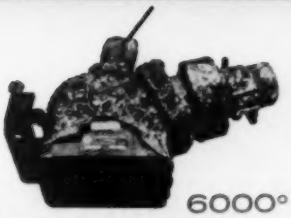
For more information, circle No. 450



6000° F.

D-65 Flexible coating—A major development in protection from rocket blast. Remains flexible. Easy to paint on at site, scrape off after exposure, and re-apply. Save time, labor. For cables, all exposed flight and ground equipment. In photo, coating has been peeled back to show Cannon Plug intact after exposure to Atlas blast.

5000° F.

Graphite molding compounds—Swift advances in handling of pre-impregnated graphite fabric in new resin systems is widening design possibilities for high temperature and ablative applications. For nozzles, exit cones and blast tube insulation. Withstands flame of solid propellant motors.

1750° F.

Metallized heat-reflective laminates—Improved metallizing techniques combine the reflectivity of thin, durable—603 gold or—101 aluminum coatings with high strength and thermal resistance of reinforced plastics. For prolonged heat exposure applications, blankets, compartment and valve protection, exhaust heat damping. Shown: typical compound contour part.

650° F.

Silicone laminates—Recent improvements in processing now allow the designer to take advantage of the inherent excellent strength retention under high heat and moisture. For airstream uses at missile speeds, nose and exit cones, fins, stabilizers, adapter and closure rings. Shown: missile tail cone.

600° F.

Phenolic laminates—High strength and good electrical properties at high temperatures characterize a fast increasing variety of Swedlow phenolic laminates. High dimensional stability and minimum thermal expansion make these laminates useful for nose cones, fins, stabilizers, adapter rings. Shown: molded switch cover and switch case.

450° F.

Epoxy laminates—Big improvements in electrical properties at high temperatures, together with highest strength and stability, and low moisture absorption, make the epoxies increasingly useful in design of dielectrics. For MIL-P-18177 and NEMA G-3 applications. Use for barriers, sheeting, capacitors, spacers, mountings, shielding. Shown: missile adapter block, and radome.

Swedlow: new advances in solving

THE SPACE AGE HEAT PROBLEM

Improved basic heat resistant materials are only as useful as the ability to combine and fabricate them into useful parts. Swedlow research is improving that ability to an extraordinary degree. Swedlow skills embrace the above and many other advanced materials. They are available with a wide variety of filler materials, in flat sheet laminates or complex molded contours. Your difficult problems in design and producibility will be welcomed by Swedlow engineers. Send for full information, Dept. 18.

Swedlow

SWEDLOW Inc. LOS ANGELES 22, CALIFORNIA • YOUNGSTOWN 9, OHIO

save more with parts that do more

THERMOSETTING MOLDED PLASTIC PARTS

Save on Sub-assembly. Here's how: by combining several properties and functions, one Formica molded part frequently replaces two or three made of ordinary materials. And by molding laminated and macerated plastic materials together, with one or more metal inserts, the Formica part becomes a *component* that's far more useful than conventional parts.

Save on Material. Formica's unique strength/weight ratio helps you improve product performance and save on direct material costs, too. It's strong as steel, has excellent impact and flexural strength, plus good electrical insulating and corrosion resisting properties. It's lighter in weight and costs about the same per pound, so you can buy several Formica molded parts for less than one comparable metal part.

Save on Replacement, too, because lighter weight means reduced wear, longer part life. And remember, molding uniformity eliminates costly machining.

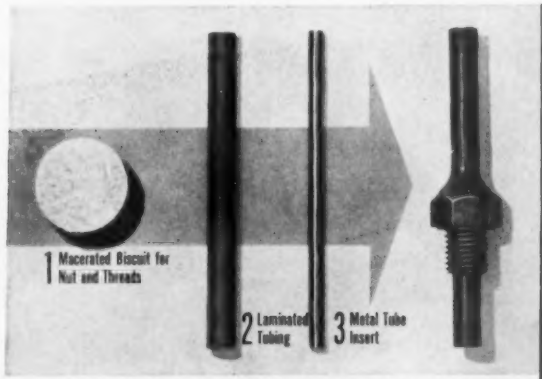
Get complete information on how Formica molded parts are tailor-made to give you exactly the right formulation of properties, functions, size, shape and finish. Use coupon below to request your free copy of bulletin 909.

FORMICA HIGH IMPACT THERMOSETTING PLASTIC PARTS COMPRESSION AND TRANSFER MOLDED

PROPERTIES	RANGE
Izod impact, ft. lbs. per in of notch	0.65 to 12.0
Dielectric strength, ⅛" perpendicular, short time, vpm	210 to 750
Flexural strength, flatwise, psi	8,000 to 25,000
Compressive strength, psi	18,000 to 35,000
Moisture absorption, 2" diameter disc (ASTM D570—57), percent	0.15 to 2.2
Chemical resistance	Resistant to mild solutions of acids and alkalies
Finishes	Sanded to mirror-smooth

BASIC FORMS—Laminated, macerated or laminated-macerated parts, compression or transfer molded, of paper, glass, canvas and asbestos cloth fillers, impregnated with phenolic, melamine, silicone, D.A.P. and epoxy resins.

APPLICATIONS—For electrical, mechanical and chemical applications in a wide range of industries including textiles, aviation, missiles, electrical/electronic, appliances, automotive, chemical, machinery, materials handling and many others.



BUILD-UP FOR SAVINGS—Formica molds laminated and macerated forms with metal tube insert to produce another do-more, save-more part. This light bulb frosting nozzle features chemical and moisture resistant properties for superior acid-carrying performance. Combining nut, thread and metal tube insert into one unit saves costly assembly and machining time.

FORMICA CORPORATION
4550 M Spring Grove Avenue
Cincinnati 32, Ohio

☐ Send free copy of Molded Products Bulletin 909.

NAME_____

COMPANY_____ TITLE_____

ADDRESS_____

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FI-2599

For more information, turn to Reader Service card, circle No. 477

BUILD IN STRENGTH AND LIGHT WEIGHT WITH N-A-X FINEGRAIN STEEL

In a wide variety of applications N-A-X FINEGRAIN—a low-alloy high-strength steel—can bring important weight savings without sacrifice of strength and safety. When you design N-A-X FINEGRAIN into your product, you get *all* these advantages:

- It is 50% stronger than mild carbon steel.
- Polishes to a high luster at minimum cost.
- Can be cold formed readily into difficult stampings without surface disturbances.
- Is stable against aging.
- Has high fatigue life with great toughness.
- Has greater resistance to wear and abrasion.
- Is readily welded by any process.
- Offers greater paint adhesion.
- Has twice the resistance of carbon structural steel to normal atmospheric corrosion.*

*Where greater resistance to extreme atmospheric corrosion is important, our N-A-X HIGH-TENSILE is recommended.

Sound like something for you? A thoroughly competent metallurgical service organization is available to work with you on any application problem you may have. Write, wire or phone Product Development Department, Great Lakes Steel Corporation, Detroit 29, Michigan.

N-A-X FINEGRAIN STEEL

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

A new family of materials to meet special problems

•

SHOCK
STRESS
ABRASION

AMSCO® ALLOYS

In addition to austenitic manganese steel castings—long known for their exceptional service life in mining, construction, quarrying and milling applications—Amsco now offers *seven* other ferrous alloy materials. These include specially alloyed manganese steels, chrome moly steels, high strength alloyed steels and alloyed cast irons.

Each has particular advantages for specific service requirements, involving various combinations of impact, stress and wear. Check the brief facts on these alloys below. Then call in an Amsco sales engineer to assist in selecting the *one best* material to meet your application needs.

AMSCO ALLOY DESIGNATION	DESCRIPTION AND USES	MECHANICAL PROPERTIES
MY	Heat-treated, chromium alloyed manganese steel ... for use in light-to-medium weight castings requiring modest improvement in growth and distortion, and increased stiffness.	tensile strength ..... 120,000 psi yield strength ..... 56,000 psi elongation ..... 45% reduction of area 30%
MML	Heat-treated, molybdenum alloyed manganese steel ... for castings requiring improved weldability, for extremely heavy metal sections, and castings exposed to excessive heating environments.	tensile strength ..... 120,000 psi yield strength ..... 52,000 psi elongation ..... 50% reduction of area 40%
MMH	Heat-treated, molybdenum alloyed manganese steel ... for use in castings requiring optimum mechanical properties and wear resistance. Provides improved stiffness and resistance to peening and flow.	tensile strength ..... 120,000 psi yield strength ..... 65,000 psi elongation ..... 20% reduction of area 18%
CML	Heat-treated, air-hardening chrome-moly steel ... for casting applications involving scouring or grinding wear. Suitable for more complex casting designs.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 10% reduction of area ..... 15% hardness ..... 275-375 BHN
CMH	Heat-treated, air-hardening chrome-moly steel ... exhibits potentially improved wear resistance over CML (above), when shock loading is not sufficiently severe to cause breakage.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 6% reduction of area ..... 7% hardness ..... 300-400 BHN
CS	Martensitic, multiple alloy steel with chromium, nickel and molybdenum ... combines high mechanical strength with good abrasion and wear resistance.	tensile strength ..... 220,000 psi yield strength ..... 195,000 psi elongation ..... 8% reduction of area ..... 20% hardness ..... 300-500 BHN
HC	High chromium cast iron ... provides outstanding abrasive wear resistance, where impact force is low but particle velocity and scouring forces are high.	tensile strength ..... 60,000 psi transverse strength ..... 7,000 lbs. deflection ..... 0.12 in. hardness ..... 400-600 BHN

For further information
—write for technical bulletin on "Amsco Ferrous Alloy Castings".

AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Illinois

For more information, turn to Reader Service card, circle No. 326

there are always good reasons for designing it in

polypropylene

After extensive testing, the material selected for this smart Hallmark radio was AviSun Polypropylene. The only material offering you so many superior properties while lowering production costs. Custom molded by Joseph Hall Tool Co.

in the Hallmark Transistor Radio

it's toughness and economy

AviSun Polypropylene was first choice for several reasons. High impact resistance—virtually mar and chip proof. Hot sun won't warp or distort the case. Higher gloss and sparkle. Pleasant to handle. Perspiration proof. All this sales appeal, *plus economy* of faster molding cycles, warrant top consideration of AviSun Polypropylene for a vast variety of products.

Yet these are but a few of its many advantages. No other material has this combination of properties:

1. **Heat Resistance**
2. **Chemical Resistance**
3. **Toughness**
4. **Economy**

AviSun's technical specialists will be glad to work with you on your specific applications. Write for Booklet AP-601 giving complete technical information.

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frenchtown engineered ceramics NEWS MEMO

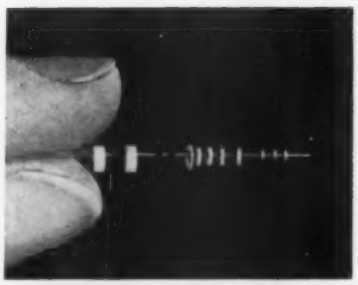
FRENCHTOWN PORCELAIN COMPANY • FRENCHTOWN, NEW JERSEY

Extremes in size shown by Frenchtown Products

The widest range of diameters in the alumina ceramic industry is demonstrated by two ceramic products currently being made at Frenchtown. Take, for example, the huge cylinder used in hydrogen fusion experiments within the C-Stellerator at Project Matterhorn, Princeton, New Jersey. Measuring 21" O.D. by 16 1/2" I.D. by 66" long, fired, this tube is produced by casting in plaster molds. A cycle of over 10 weeks is required from the preparation of mold until the ware is removed from the

kiln. Weighing over 1500 pounds, these rough castings are believed to be the largest ever produced in aluminum oxide ceramics. Subsequent diamond grinding to precise final dimensions consumes another 8 weeks.

Contrast the above with miniature semi-conductor packages, measuring .050" O.D. by .030" I.D. by .010" thick, numbering 600,000 pieces per pound. Both are made from the same

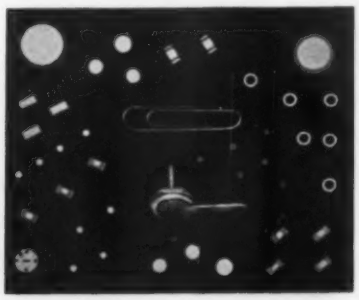


alumina ceramic material, Frenchtown's well-known #4462 Almanox.®

If you would like to investigate how Frenchtown engineered ceramics can make your product better, write stating your problem. A blueprint or sketch with specifications will bring complete information.

Beryllium Oxide Ceramics now offered by Frenchtown

Combining excellent electrical properties with high thermal conductivity, Frenchtown beryllium oxide ceramics are available in molded and extruded shapes. An extensive series of compounds with beryllia contents up to 95% affords the user a wide choice of properties, including great mechanical strength.



Frenchtown's Molcote® metallized coating may be applied to selected areas for subsequent assembly with metal parts through brazing or high-temperature soldering. Nickel, copper, gold and other plated metals are applied over the Molcote® as specified.

Demand for beryllium oxide ceramics as semi-conductor packages indicates a widespread acceptance of this material for use where heat-sink function is coupled to that of electrical insulator. Nuclear instruments and control apparatus also make extensive use of beryllium oxide's unique properties. A Frenchtown Sales Engineer would be happy to discuss specific problems with you involving the use of these versatile ceramics. No obligation, of course.

Semi-conductor Package Ceramics by Frenchtown

Headers, pads, cases, mounts, and other semi-conductor package items are being supplied by Frenchtown. Available in aluminum oxide and beryllium oxide ceramic materials, these specialties are offered either plain or metallized. Frenchtown's Molcote® metallized coating can be applied to specified areas for ceramic-metal assembly by brazing or high-temperature solder. Complete packages, including lids, bottoms, leads, and other metal parts are produced to order.

Of special interest are diode mounts with beryllium oxide pads, providing excellent heat-sink characteristics, combined with electrical insulating properties. Literature is available. Ask for Bulletin 1060.

For more information, turn to Reader Service card, circle No. 375

What a heel!

Achilles' mother was sure she had outfitted her fabled fighting son in the best of armor. She had ordered Washington Steel's ColorRold Stainless specifically for this critical purpose. No soldier in the Trojan War had been so carefully prepared for battle. But she made one fatal mistake. In fabricating the suit of armor she ran out of stainless steel and had to substitute a less noble metal for Achilles' right ankle. Paris, getting wind of this substitution, took dead aim at Achilles' heel, and down he went—not more than twenty minutes after this picture was taken.

There is no substitute for stainless steel whether you are building a skyscraper, a space vehicle or a kitchen sink. Washington Steel's ColorRold stainless enables you to enhance the beauty of your quality product. Don't be an Achilles Heel—Never try to substitute for stainless steel.

WASHINGTON STEEL CORPORATION

and ColorRold®

PRODUCERS OF *MicroRold®* STAINLESS SHEET & STRIP

WASHINGTON, PA.

For more information, turn to Reader Service card, circle No. 486

DOW

NEWS ABOUT PRODUCT DESIGN AND MATERIALS

Thanks in part to modern plastics, today's product designers are able to come up with solutions to design problems that would have been impossible a decade ago. The success of their efforts points up the increasing importance of communication between designer and plastic producer. Here, on these pages, are a few ideas that were born of this communication . . .

FROM REFRIGERATOR CARS TO PORTABLE RADIOS ...PLASTICS SOLVE DESIGN PROBLEMS!

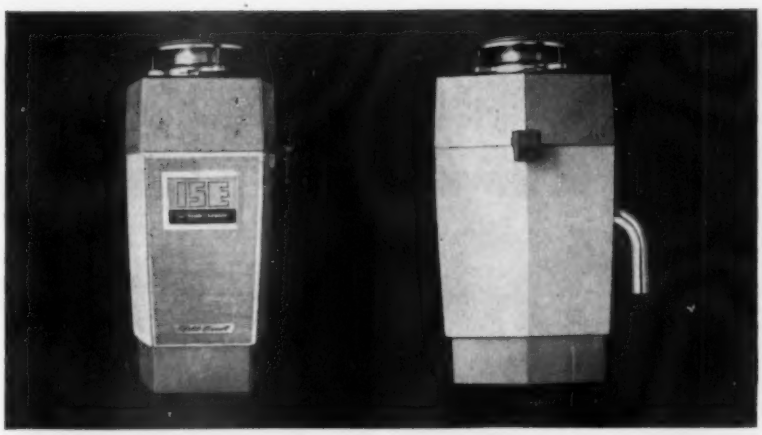
New refrigerator car hatch cover, preform-molded from thermosetting resins made with Dow monomers, retains its shape, dimensions, protective qualities under severe operating conditions!

Refrigerator car hatch covers take a beating from weather, hard use, and corrosive brine. Molded hatch covers, preformed with Dow-monomer-based polyester resins, prove they can take it, and save money for the user as well!

Reinforced polyester moldings are low in cost. Nearly any configuration, hole, slot, fillet, or rounded edge can be formed in the mold, greatly reducing the number of costly production operations normally required by other materials. What's more, they have excellent resistance to weathering, temperature extremes, and to the attacks of salt and other chemicals; they won't warp or lose their strength; and they last for the life of the car, with little or no maintenance.

Preform moldings offer advantages in cost, in production ease, in long life under difficult service conditions, and the types of products for which they can be used are virtually unlimited. Reinforced molding with Dow-monomer-based thermosetting resins is currently gaining favor in the automotive and appliance industries for heater housings, various refrigeration units, and other parts requiring a strong, rigid, temperature-resisting material. Dow is an experienced supplier of the basic monomers for polyester resins for premix, preform and mat moldings.

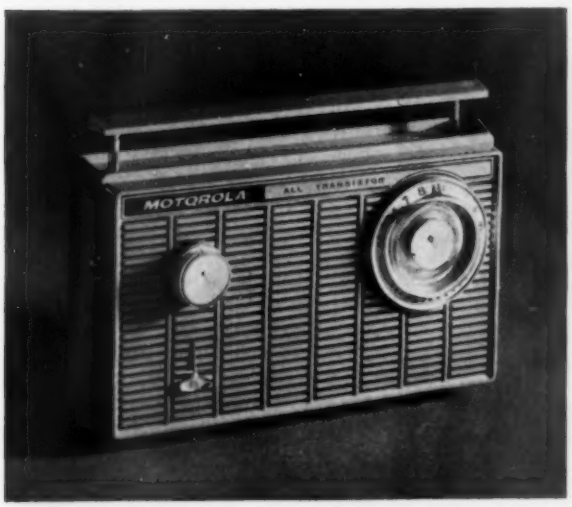
Designers who direct their efforts toward products with sales appeal also have a challenging assignment. Here's how Dow plastics help solve design problems for a garbage disposal unit, a portable radio, and a toilet tank refill and flushing unit.

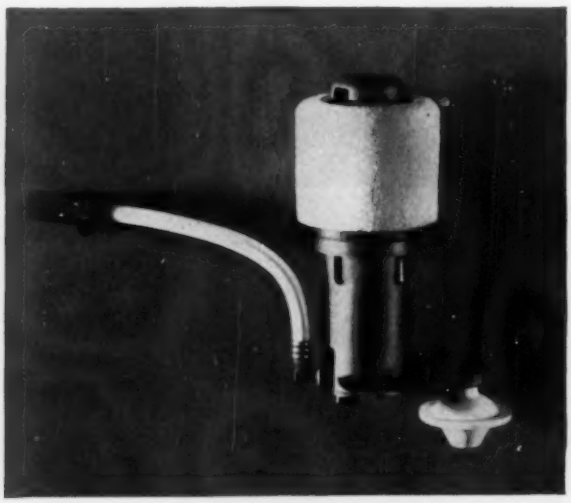


"Whisper-quiet" shredding and grinding is a sales point emphasized by the maker of this sleek new model sink-type garbage disposal unit. And the "silent treatment" is achieved by a cushioning inner lining of expandable polystyrene in bead form, foamed-in-place by the manufacturer. The attractive, high gloss outer casing is molded of Styron® 475—a high-impact formulation of Dow polystyrene. It resists heat, food acids, and can be molded or extruded in almost any color.

Design for rugged going. This new portable radio lightens the load while its attractive case stands up well to rugged going. Molded from Styron 369 – medium impact and heat resistant polystyrene—it takes the bumps and bruises of travel in stride. Toughness of the case provides a margin of safety against breakage, even if dropped! In addition, high surface gloss and molded-in color add extra sales appeal. Whether it goes on picnics or just to the patio, the case stays rich looking, shrugs off scuffs and stains, won't fade or discolor in bright sunlight.

Another design in Styron is this toilet tank refill and flushing unit. Molded of Styron 475M for high impact and easy flow, the casing will withstand a lifetime of underwater service without rusting, corroding or warping. Even the screw threads are molded of Styron—proof of its exceptional molding characteristics. The float mechanism takes advantage of the buoyancy of Styrofoam® – Dow expanded polystyrene. Styrofoam won't crumble or flake in use, and won't support mold growths. It has outstanding water penetration resistance.





MAY WE WORK WITH YOU on a design problem involving the use of plastics materials? The complete facilities of the Dow plastics research and development staff, and the marketing and merchandising department are at your service. Drop us a line. THE DOW CHEMICAL COMPANY, Midland, Mich., Plastics Merchandising Dept. 1725CD11.

See "The Dow Hour of Great Mysteries" on NBC-TV

THE DOW CHEMICAL COMPANY

Midland, Michigan

DOW

For more information, turn to Reader Service card, circle No. 360

ENJAY BUTYL

IS TOPS IN ALL-'ROUND

RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.

VIVID COLORS

Enjay Butyl requires no additives for quality coloring over a wide range of hues. Famous for colorability and smooth finishes, Butyl has been successfully plastic coated for special applications.

RESISTANCE TO TEAR AND ABRASION

Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

RESISTANCE TO SUN-LIGHT AND WEATHERING

Enjay Butyl has proven its resistance to ultra-violet light, ozone, oxidation, moisture and mildew. Increases life of products such as weatherstrips, garden hose, wading pools and automotive parts.

RUBBER

PERFORMANCE

DAMPING PROPERTIES

Enjay Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.

IMPERMEABILITY TO GASES AND MOISTURE

Enjay Butyl is tops in impermeability to gases and moisture . . . retains air pressure 8 times better than natural rubber. Outperforms other rubbers in such application as inner tubes, jar and bottle seals, hoses and inflatable goods.

ELECTRICAL RESISTANCE

Enjay Butyl tops all vulcanizable rubbers in electrical and dielectric properties . . . in resistance to corona and ozone breakdown and water absorption. Its high dielectric strength insures against electric breakdown under normal or surge voltage. Its heat resistance permits higher current flow for a given conductor size.

The outstanding properties of Butyl Rubber create new horizons for the designer, and offer to manufacturers an opportunity to utilize the qualities of rubber in applications never before possible. The unique properties of Butyl have led to vast improvement in many existing products. Technical skills will open the way to countless new uses.

Butyl is the "idea" rubber with uses stretching as far as the imagination can reach. We'll be glad to tell you all about it. Just contact the nearest Enjay office.

HOME OFFICE: 15 West 51st Street, New York 19, N. Y. OTHER OFFICES: Akron • Boston • Charlotte • Chicago • Detroit • Houston • Los Angeles • New Orleans • Tulsa

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY® BUTYL

For more information, turn to Reader Service card, circle No. 368

Vacuum Melting Extracts Impurities

Improved soundness, better hot and cold workability, higher mechanical properties, cleaner metal with lower gas content—these are the characteristics of vacuum melted steels from Allegheny Ludlum.

Typical of the metals produced by vacuum melting are Consutrode® steels and alloys. They provide outstanding cleanliness and homogeneity at minimum cost. These alloys, pioneered by Allegheny Ludlum, are available in the largest ingot sizes of any vacuum melting process—up to 20,000 lb. ingots. This makes possible larger products of high quality in super alloys, stainless, tool, and low alloy steels.

Consutrode alloys are made by vacuum remelting electrodes of a predetermined composition by an electric arc. The white heat of the arc—8000 F—breaks down many nonmetallics in the electrode. Considerable degasification, as well as substantial improvement in cleanliness, is achieved by the furnace vacuum which removes the oxides and nitrides released in melting of the electrode.

Controlled solidification of the molten metal in a water-cooled crucible is a principal advantage of the consumable electrode vacuum process. This gives an exceptionally sound and homogeneous ingot.

Other recently developed methods for improving steels and properties of the improved alloys are described in a new booklet, "Modern Melting at Allegheny Ludlum." It includes a description of Special Air Melted Steels, Invac alloys made by induction vacuum melting, Invacutrode alloys made by remelting Invac electrode stock by the consumable electrode vacuum process, and Consutrode alloys.

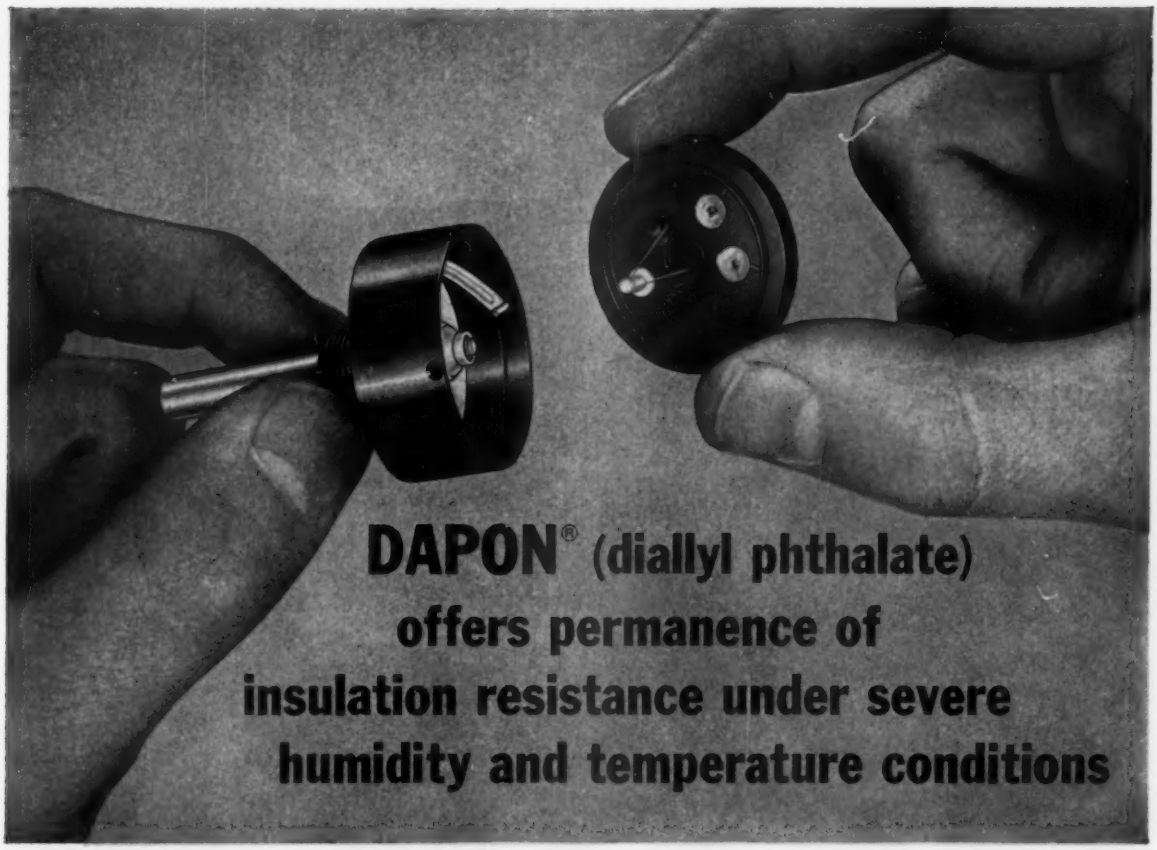
This new booklet is packed full of charts and graphs—a real help to anyone who must get the most out of metals. Ask your A-L representative for a copy or write: ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept. MM-11.***

ALLEGHENY LUDLUM

PIONEERING on the Horizons of Steel

2116

For more information, turn to Reader Service card, circle No. 321



DAPON® (diallyl phthalate) offers permanence of insulation resistance under severe humidity and temperature conditions

This plastic is ideal for applications where changes in humidity can affect electrical values. DAPON can prevent costly "in service" failures in electrical and electronic components.

A new molded plastic potentiometer produced by New England Instrument Company features exceptional resistance to humidity, high reliability and low noise. A raised conductive plastic ring is used in place of resistance wire in these miniature units. The new potentiometers are ideal for servo and instrumentation applications where long life and extreme accuracy are important factors.

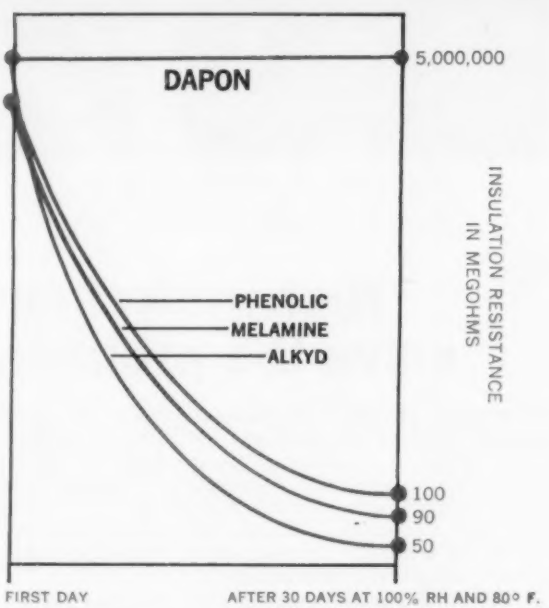
The solid resistance element, insulating base and silver terminal leads are molded in one operation with DAPON (diallyl phthalate) Resin. Result: a single, almost indestructible precision unit.

New England Instrument chose DAPON because of its superior electrical and physical properties, and its low moisture absorption. DAPON also molds easily around metal inserts without cracking, and withstands extremes of temperature, vibration and shock.

Specify DAPON (diallyl phthalate) Resin when you need:

- Low dielectric loss
- High dielectric strength
- Superior dimensional stability
- Excellent arc resistance
- High volume and surface resistance after high humidity-high temperature conditioning

Write for FMC's data sheet containing technical information about DAPON, suggested uses for this resin, and the names of DAPON compounders.



FOOD MACHINERY AND CHEMICAL CORPORATION
Dapon Department
161 East 42nd Street, New York 17, New York

For more information, turn to Reader Service card, circle No. 373

Heat resistance plus high hot-strength are critical requirements in these heavily-loaded trays and fixtures, carrying truck gears through a carburizing system. Trays and fixtures are Type HT* high-nickel alloy castings. This alloy is one of five whose high-nickel content—over 25%—gives them unequalled resistance to elevated temperatures and carburizing atmospheres.

High-nickel alloy castings help solve the problem of thermal fatigue

What's your problem with thermal fatigue? You can probably solve it, economically, by selecting from today's high-nickel casting alloys. Their strength and ductility combined with a relatively low coefficient of thermal expansion result in high resistance to repeated thermal shocks. They're delivering impressive service in heat treating, chemical processing and many other demanding applications.

In this versatile family of austenitic nickel-chromium-iron alloys, you'll find useful strength and long life at temperatures from 1200 to 2300°F.

You'll find remarkable combinations of high tensile strengths, stress-to-rupture values, creep resistance. You'll find properties to withstand many oxidizing and reducing environments, carburizing and nitriding atmospheres.

Special resistance to scaling, to thermal shock, stress-corrosion cracking or sigma phase embrittlement are among other useful properties offered by alloys in this group.

And there's valuable design information—plus full data on these alloys—in the new 64-page booklet, "Heat Resistant Castings, Corrosion Resistant Castings . . . Their Engineering Properties and Applications." A copy is yours for the asking.

*Alloy Casting Institute designation

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL
NICKEL MAKES ALLOYS PERFORM BETTER LONGER

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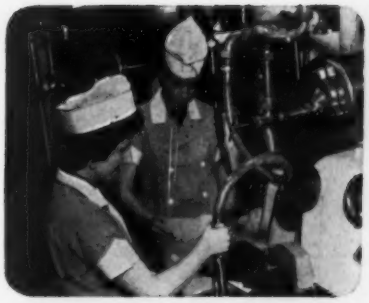
Here are five ways to use versatile-flexible

TYGON®

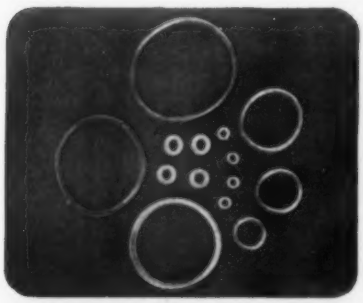


AS TUBING OR HOSE to pipe taste-sensitive liquid foods or corrosive chemicals. Tygon Tubing is glass-clear, flexible as a piece of string, resistant to acids and alkalies, non-toxic, sterilizable, and is made in bores from 1/16" to 4".

AS A PAINT to protect plant and equipment from attack by corrosive fumes and gases. Applied by brush or spray, Tygon air dries quickly to form a tough impermeable plastic skin that shrugs off acids, alkalies, oils, water and alcohols.

AS A HEAVY-DUTY LINING to protect the interior of pickling, plating, chemical processing and storage tanks from destruction by corrosive solutions. Easier to install than rubber linings, Tygon can be applied to tanks of any size or shape.

AS A CORROSION-RESISTANT GASKETING. Tygon shows no chemical deterioration with age. Gaskets remain flexible and tight, unaffected by weather or exposure to chemicals. Tygon gaskets are available in an almost unlimited size range.



AS MOLDED ITEMS. Tygon's toughness, durability and flexibility, coupled with staunch chemical resistance, offer pronounced performance characteristics for grommets, washers and molded mechanical goods items in virtually any shape.

Few materials offer more versatility in use than the Tygon series of thermoplastics. In whatever form they are used: tubing, coatings, sheet materials or molded goods, the Tygons are characterized by superb resistance to chemical attack. It shrugs off with equal ease both acids and alkalies. If corrosion is a problem in any product you make, Tygon may prove the perfect answer.

WRITE TODAY for the TYGON PORTFOLIO. *Pertinent data and technical characteristics of the various Tygon compounds to enable you to determine just how you can use Tygon most advantageously. Free, on request. Address Dept. MM-1160.*

PLASTICS AND SYNTHETICS DIVISION

U. S. STONEWARE

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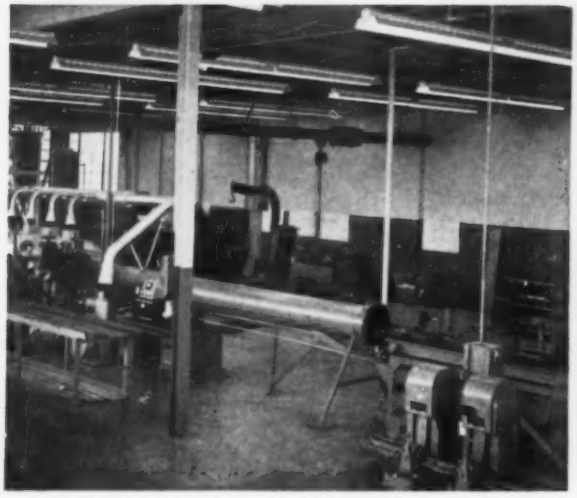

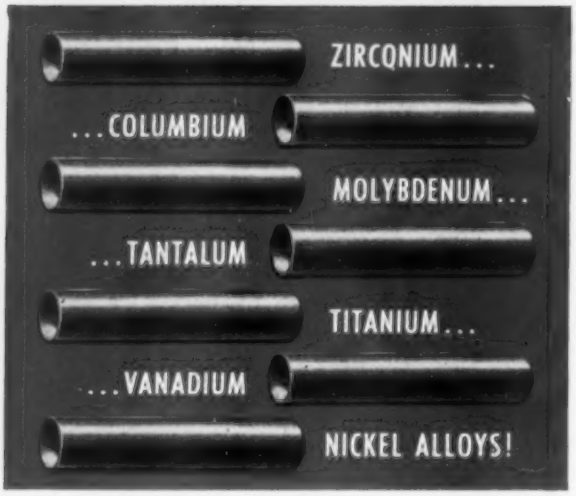

You can buy Wolverine tube in special metals—right now!

For more than five years, using the tubing industry's largest and most complete research and development facilities, Wolverine Tube research engineers have been working with zirconium, columbium, molybdenum, tantalum, titanium, vanadium and nickel alloys.

Thus, the know-how is now available to permit American industry to specify seamless tubing manufactured from these metals – tubing with extremely high temperature properties and great corrosion resistance among other valuable physical attributes.

Wolverine Tube would be happy to discuss with you the list of applications where tubing made from these metals can help your company do a better job, more economically.

Write or call for more information–or "Ask Your Wolverine Tube Salesman–He Knows!"

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. G 17258 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality Controlled Tubing

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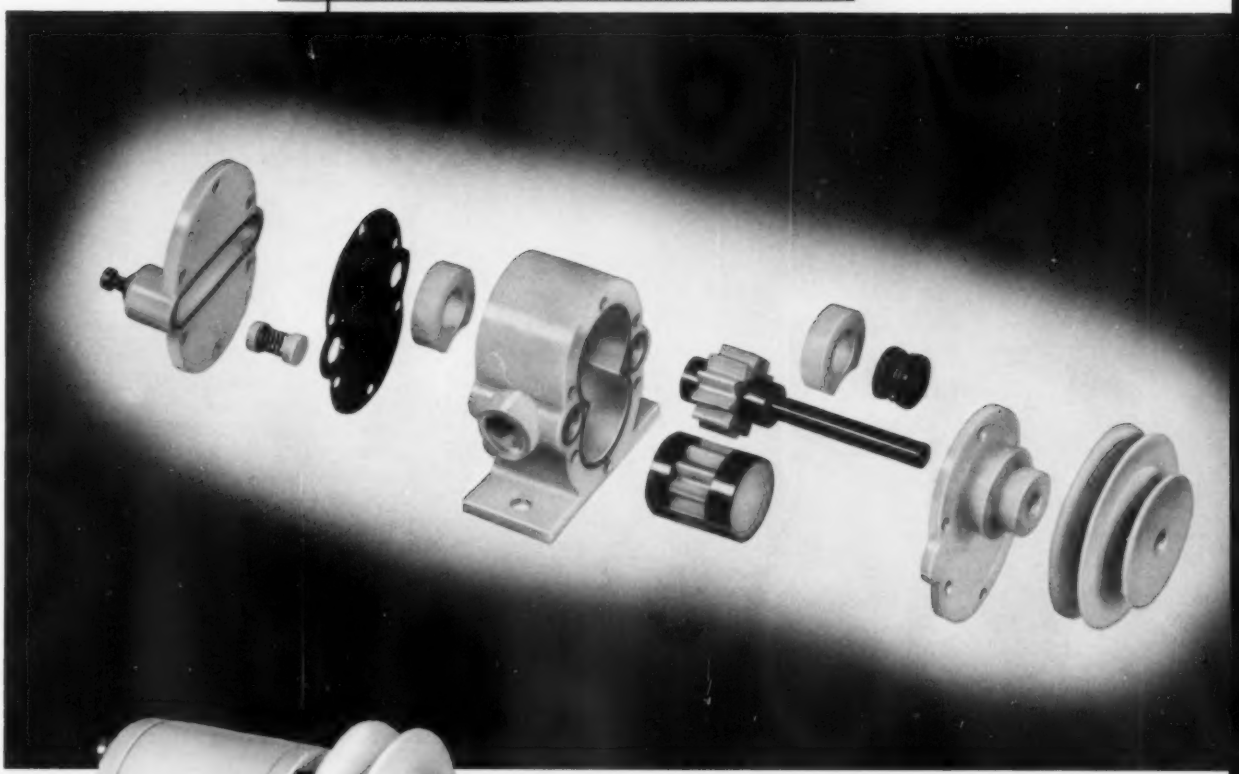
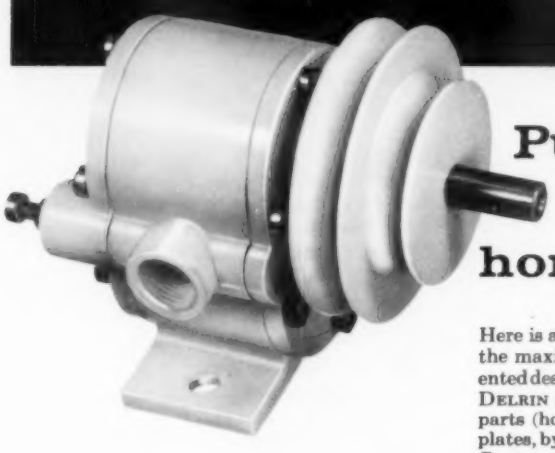
For more information, circle No. 482 ➤

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials





Pump parts of DELRIN® cut costs...reduce horsepower requirements

Here is a new gear pump that attains the maximum advantages of its patented design features by using Du Pont DELRIN acetal resin for all the major parts (housing, gears, bearings, cover plates, bypass valve and drive sheave). Compared with rotary pumps now made in brass and other metals, the new pump of DELRIN has better efficiency, less heat buildup, improved bearing characteristics with no lubrication, quieter operation and longer life. The manufacturer reports that the low friction of DELRIN reduces horsepower requirements as much as 50% over comparable models in brass.

In addition, economical injection molding of these parts to close tolerances—plus the elimination of expensive finishing operations—provides the greatest possible savings in pump cost. The pump parts are molded by Artag Plastics Corporation and Chicago Molded Products for Planet Products of Chicago, Illinois.

As in most applications, it is a *combination* of property advantages that makes DELRIN outstanding in performance. The different parts of the pump depend, in varying degrees, on such properties of DELRIN as: high strength, stiffness, creep resistance, corrosion resistance, non-lubricated bearing characteristics, low friction, dimensional stability, abrasion resistance and excellent fatigue life while subjected to a range of temperatures and environments.

On the following page, you'll find more examples of how these properties are being used to improve the performance and lower the production costs of a variety of pumps. The details may well stimulate your thinking about the advantages of DELRIN for *your* products.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

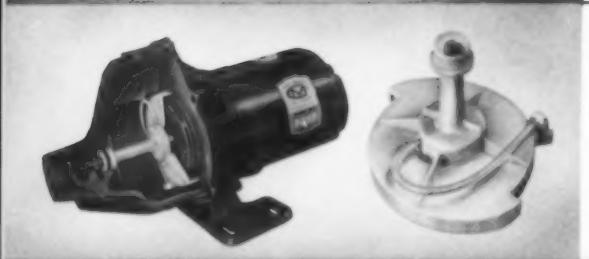
working with

Du Pont Delrin®

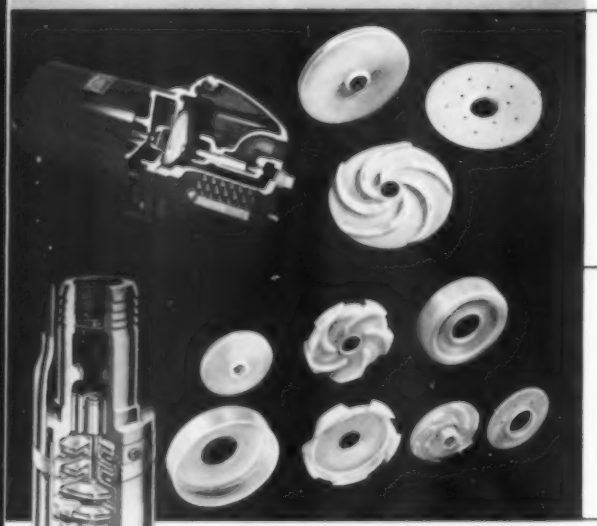
one of Du Pont's versatile engineering materials

How parts of DELRIN® improve pump performance

WALKER lubricator uses DELRIN for the pumping unit of a new improved central lubricator for vehicles. Here the high temperature strength of DELRIN is a prime requirement—the pump body must withstand under-the-hood temperatures up to 250°F. Pump body, cap, check valve and tube connector are all economically injection-molded of DELRIN. They meet the exacting mechanical requirements for the pump in addition to providing major savings in manufacturing costs. (Molded by G. Felsenthal and Sons, Chicago, Illinois, for Walker Manufacturing Co., Racine, Wisconsin.)



CLAYTON MARK jet pump has an improved volute housing and venturi assembly of DELRIN, replacing the former combination of cast iron and brass, and offers significant advantages in both cost and pumping efficiency. Creep resistance, abrasion resistance and dimensional stability, even under elevated temperatures, are necessary here. The two parts of DELRIN are easily and economically joined by spin welding. (Molded by Chicago Molded Products, Chicago, Illinois, for Clayton Mark Company, Evanston, Illinois.)



RED JACKET "Trailblazer" jet pump uses new injection-molded impellers of DELRIN, because these parts give superior performance over comparable models in brass through increased efficiency, greater abrasion resistance, reduced mineral buildup and longer life. In addition, the use of DELRIN resulted in a 35% saving in impeller costs. (Molded by Chicago Molded Products, Chicago, Illinois, for Red Jacket Manufacturing Company, Davenport, Iowa.)

RED JACKET "Custom Submerga", a new submersible pump, uses DELRIN to achieve new high standards of performance and dependability. In each of the stages, DELRIN replaces brass for the impeller, bowl and diffuser. The fatigue endurance, strength and resistance to creep and corrosion of DELRIN are particularly valuable. According to the manufacturer, precision-molded parts of DELRIN provide an 85-90% cost saving over comparable parts in brass.

These are only a few examples, selected from one particular field, of the many ways in which DELRIN is improving designs and effecting economies in hundreds of applications across a broad range of industries. Why not translate the cost and performance advantages of DELRIN acetal resin in terms of your product? Mail the coupon below for further information.

POLYCHEMICALS DEPARTMENT

DU PONT

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BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.), Dept. B-1
Room 2507-D Nemours Building, Wilmington 98, Delaware
I am interested in evaluating DELRIN for the following use:

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*Name*_____

*Company*_____ *Position*_____

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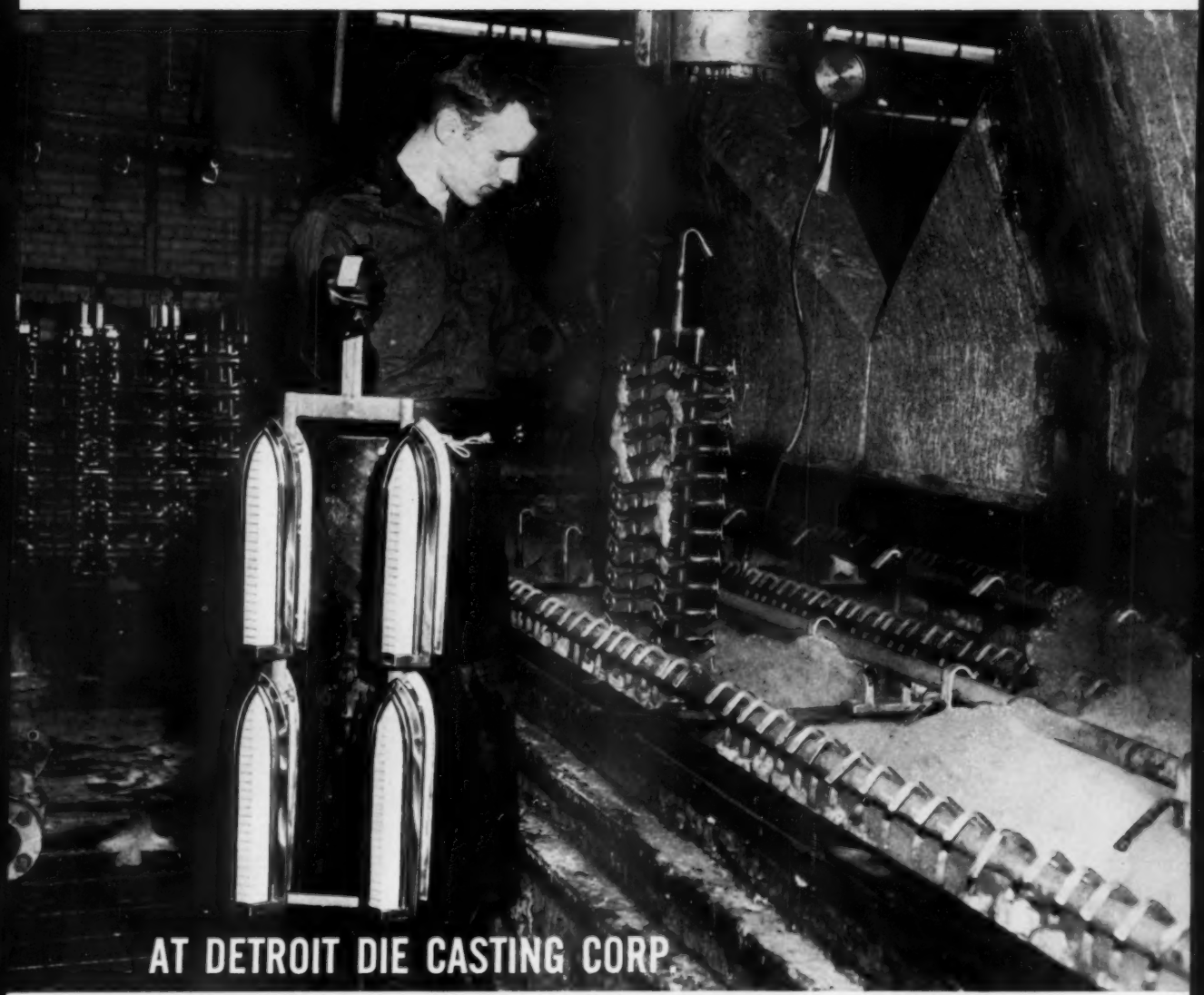
*City*_____ *Zone*_____ *State*_____

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

DELRIN® *acetal resins*

one of Du Pont's versatile engineering materials

Alathon® · Zytel® · Lucite®



Maximum Smoothness on Zinc Die Castings Obtained With OFHC® Anodes

Eliminate roughness by plating zinc die castings with *impurity-free* OFHC Anodes... and cut scrap loss too! Detroit Die Casting Corp. of Detroit, Michigan, finds that OFHC Anodes dissolve uniformly in copper cyanide baths, yielding smoother deposits on zinc die castings for automotive parts. *Even with cathode current densities varying from 30 to 60 amps per square foot.* And because OFHC Anodes keep producing up to the solution level, downtime for anode changeover is reduced. Detroit Die Casting credits OFHC Anodes for enabling trouble-free plating in extended production runs.

More Usable Copper Per Pound... Less Anode Scrap

OFHC Anodes are the purest copper anodes produced—99.99+% copper, the only copper anodes completely free of oxides and residual deoxidants. Their density is equal to that of rolled anodes. Purity and density result in more uniform dissolution, less scrap loss... *more usable copper per pound of anode.*

Free technical publications to help you obtain better plating—and at the same time lower costs—are available from your OFHC Anode Distributor, or directly from AMCO Technical Service Section. Ask for them today.

AMCO DIVISION
American Metal Climax, Inc.
1270 Avenue of the Americas
Rockefeller Center, New York 20, New York

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For more information, turn to Reader Service card, circle No. 483

Quality is Precision and People and Pride

We make and sell laminated plastic sheets, rods, and tubes. But nearly all of our customers prefer us to fabricate their parts from these materials.

Synthane quality starts with the rigid inspection of incoming raw materials. From this point forward, to the finished laminate, control is the byword. In fabricated parts, too, quality is precision, people and pride. Measuring instruments of all kinds, many of our own design, gauges, precision tools and other specialized equipment all contribute to Synthane quality products. Our people, through years of experience, know how to machine laminated plastics to achieve the dimensions and tolerances you require.

Quality is a matter of pride on the part of every Synthane craftsman who works on your job. And sixty per cent of our people have been with us for 10 years or more.

Aside from the first class job Synthane gives you, it will hardly pay you in money or headaches to do your own machining. Ask your Synthane representative for a quotation. You'll find him in the classified telephone book of any principal city or write Synthane Corp., 3 River Road, Oaks, Pa.

You furnish the print—we'll furnish the part

SYNTHANE
CORPORATION OAKS, PENNA.

Sheets • Rods • Tubes • Fabricated Parts
Molded-laminated • Molded-macerated

For more information, turn to Reader Service card, circle No. 451

For more information, circle No. 459 ➤

LOWER YOUR FINISHING COSTS with WALLINGFORD

Bright Annealed Stainless Steel Strip

Conventional steel making is inadequate when you require decorative stainless steel strip with an extra bright finish to pass rigid corrosion tests. "Bright Annealing" is the answer – and Wallingford is the first steel maker to apply this process to its regular production of stainless strip!

How does "Bright Annealing" lower finishing costs? By preventing formation of oxide scales present after conventional annealing and by eliminating the need for further processing which often dulls the finish. Preservation of the bright surface produced by highly polished rolls results in a finish so excellent that users find that buffing time is greatly reduced, affording significant savings.

Superiority in facilities, research and skill enables Wallingford to produce "tonnage on a laboratory basis" and make quality strip available economically.

SEE NEXT PAGE FOR MORE INFORMATION ON BRIGHT ANNEALED STAINLESS STEELS

THE WALLINGFORD STEEL CO.

WALLINGFORD, CONNECTICUT, U.S.A.

COLD ROLLED STRIP: Super Metals, Stainless, Alloy
WELDED TUBES AND PIPE: Super Metals, Stainless, Alloy

COMPLETE AND MAIL REPLY POST CARD TO RECEIVE YOUR COPY OF OUR NEW FOLDER ON STAINLESS STEEL STRIP, "TONNAGE ON A LABORATORY BASIS"

☐ Please send me your "Tonnage On A Laboratory Basis" Folder (Form No. G-1333).

☐ Have your representative call to discuss my finishing requirements.

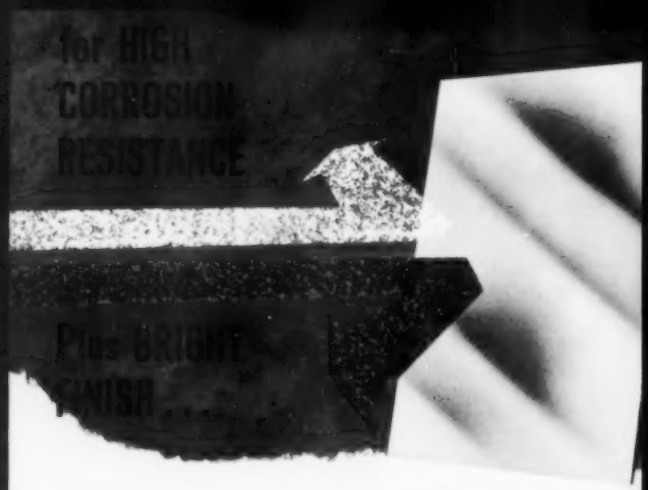
Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

**JUST COMPLETE ABOVE AND MAIL –
NO ADDRESSING OR POSTAGE REQUIRED.**



WALLINGFORD

Bright Annealed Stainless Steel Strip

Stainless steel derives its resistance to corrosion from the presence of chromium, so any depletion of chromium during processing must be avoided.

Because of Wallingford's success in this area, Wallingford Stainless Steel passes even the most rigid corrosion tests set up by leading manufacturers. Exceptional corrosion resistance is of prime importance when the stainless steel is to be used for decorative purposes and may be exposed to weather, salt water, or other corrosive elements.

In producing this stainless steel strip, Wallingford employs bright annealing. Result? Reduced customer buffing costs PLUS corrosion resistance and a bright finish never before attained!

Whether your problem is brightness of finish or the degree of corrosion resistance, Wallingford can supply stainless steel strip that will satisfy.

> Widths from 0.150" to 27". Thicknesses down to .0005". Extremely close tolerances are maintained.

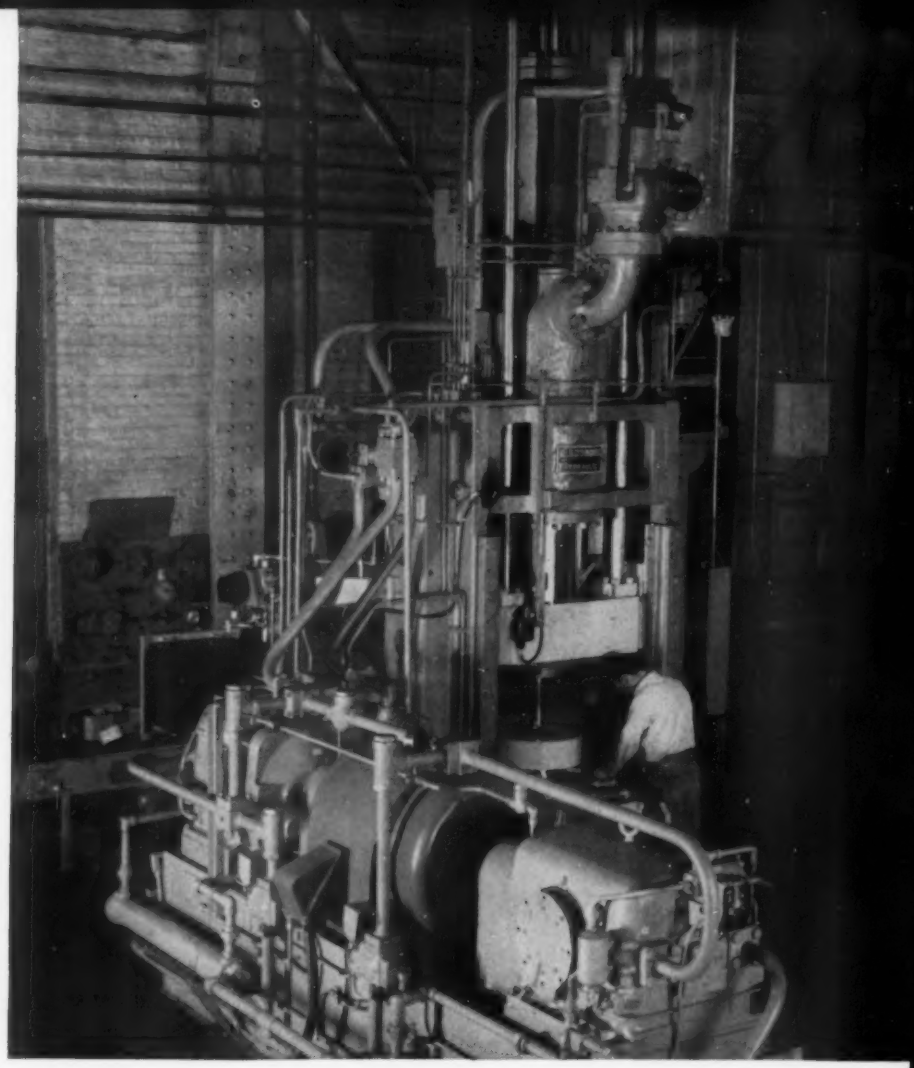
COMPLETE REVERSE SIDE OF REPLY CARD BELOW AND MAIL TO RECEIVE NEW STAINLESS STEEL STRIP FOLDER, "TONNAGE ON A LABORATORY BASIS"

FIRST CLASS
PERMIT NO. 116
Wallingford, Conn.

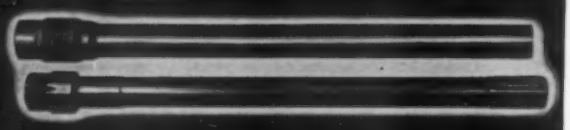
BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States
—POSTAGE WILL BE PAID BY—

THE WALLINGFORD STEEL CO.
Wallingford, Connecticut

MDE



This 500-ton hydraulically operated press built by Birdsboro Steel Foundry & Machine Company, Birdsboro, Pa., and featuring Republic ELECTRUNITE Hydraulic Fluid Line Tubing, is used by a leading research center for deep drawing, extruding, or planishing metals.



REPUBLIC DIE-FORM CUTS PRODUCTION COSTS. Ford Tractor Power Take-Off Counter-Shaft costs less to produce using a Republic Die-Form Blank, as compared to previous materials. Because Republic Die-Form Blanks closely approximate the completed part, they minimize required machining and reduce handling costs. In addition, the nature of the Die-Form Process improves machinability of any given analysis, permitting further savings through use of higher speeds and feeds. Photo below shows a Die-Form Blank and the completed shaft as featured in the Ford Tractor. Write for Die-Form Folder ADV-746.

REPUBLIC CAP SCREWS PROTECT SHAKER SCREEN PERFORMANCE. Sorting and sizing ton after ton of jolting, jarring, abrasive material is all in a day's work for Ty-Rock Vibrating Screens, built by The W. S. Tyler Company, Cleveland, Ohio. Satisfactory performance under these brutal conditions not only requires design and manufacturing skill, but a thorough knowledge of materials. Maximum performance under all operating conditions is typical of Republic's complete line of top-quality Cap Screws. Send coupon for data.

Stubborn resistance to fatigue...

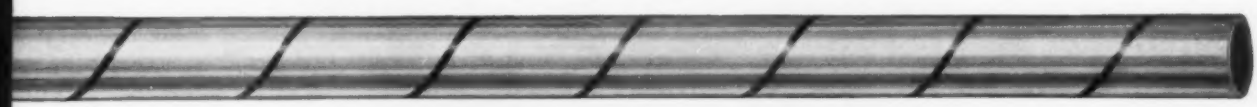
REPUBLIC ELECTRUNITE HYDRAULIC FLUID LINE TUBING

Machine tool builders and operators depend upon Republic ELECTRUNITE® Hydraulic Fluid Line Tubing for stubborn resistance to fatigue. Reason is the *consistent uniformity of concentricity* and mechanical properties of ELECTRUNITE welded steel tubing—characteristics that make this tube better able to withstand the vibrations of rapid multiple cycling.

This uniform concentricity—inherent in the ELECTRUNITE process—coupled with uniform heat treatment, insures uniform flaring characteristics. Uniform ductility assures easy bending. Both mean savings in original and in replacement installations.

You can recognize this best of all hydraulic line tubing by the blue spiral marking stenciled end-to-end on every length. It is your assurance of genuine ELECTRUNITE quality. The spiral marked tube is available in all sizes shown in JIC Standards, and is produced in a wider size range to Specification HL-1, which meets all JIC Standards test requirements.

Get all the facts. Discover how Republic ELECTRUNITE Hydraulic Fluid Line Tubing can substantially reduce maintenance costs in the most complicated installations. Call your Republic representative, or send coupon for additional information.



REPUBLIC WEDGE-LOCK PARTS® STORAGE UNITS are easy to load and unload from either side. And, the heavier the load, the tighter the grip, because patented Wedge-Lock construction includes a post that will not buckle, a concealed sway-proof joint, and a reinforced shelf that does not sag. Unlimited shelf arrangements. Capable of exceptionally high stacking. Republic Storage Engineering specialists will help you plan. Call your Republic representative today.

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New J-M fiber glass topliner absorbs distracting noise

ACOUSTICAL DEVELOPMENT MADE WITH FIBER GLASS BY JOHNS-MANVILLE WILL ADD BEAUTY, COMFORT AND SAFETY TO MANY 1961 CARS

You have only to recall the skin-thin fabric covering usually stretched over your head to appreciate the J-M

acoustical topliner . . latest insulation contribution by Johns-Manville to the comfort of modern passenger automobile interiors.

The gently-curved fiber glass liner is molded to fit the interior contours of the top of the car . . . faced with easily-cleaned fiber glass fabric in beautiful decorative colors.

This revolutionary one-piece liner increases headroom and is easily installed by the car maker—a good example of the way Johns-Manville developments are serving the industry. Another example: the J-M hoodliner—an under-the-hood fiber glass liner that is quieting engine noise on most 1960 car makes. Wider 1961 use is already planned.

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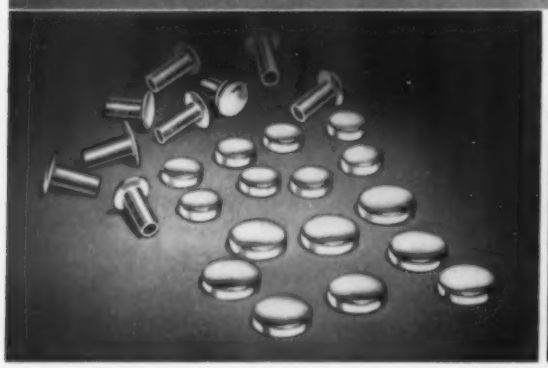
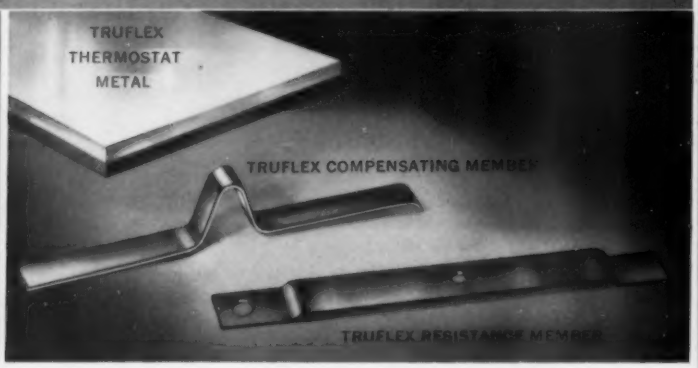
General Plate Clad Metals





1. Clad Contact Rivets and Buttons—Proctor-Silex Corporation engineers found that General Plate Contacts carried a unique warranty that was only possible because of General Plate's quality control of the entire manufacturing process — melting, rolling, fabrication. Certified AQL inspection reports are available with shipments.

2. Truflex® Thermostat Metal—General Plate Truflex Thermostat Metal is supplied in strip form which Proctor-Silex Corporation blanks and forms into the main bimetal element and compensating member.

Truflex Thermostat Metal is available in cut-to-length strips or long continuous coils to meet your needs. Truflex is also furnished in formed elements or completed assemblies to meet the most exacting parts specifications.

FREE: Write for your free Truflex Nomograph Calculator for plotting first sample size determinations.

Team Up to Cut Costs...

AND IMPROVE PERFORMANCE FOR **PROCTOR-SILEX CORPORATION** IN THEIR VARITHERM* INFINITE CONTROLLER

1 *Silver Clad Electrical Contacts*

2 *Truflex Thermostatic Bimetal*

3 *Clad High Conductivity Spring Metal*

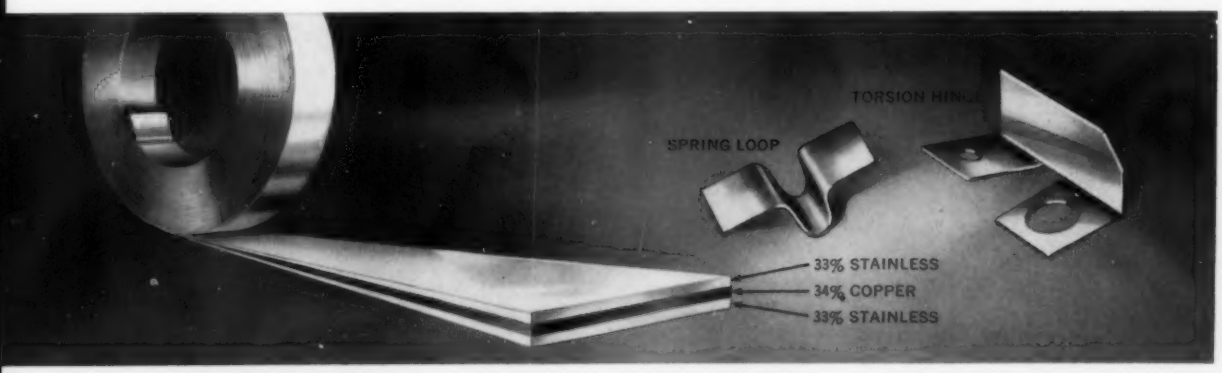
The new, unique Proctor Varitherm provides unlimited heat settings that are uniform over the entire heating element. Eliminating rheostats and transformers, it works on an *on-off system* to maintain constant heat at any setting.

Three different General Plate Products are used, as illustrated. They were selected, first because clad metals are required in order to produce desired *combinations* of *characteristics*, and, second, because we recommended and can produce special *combinations* of *metals* that materially improved the performance of this remarkable new controller.

These three General Plate Products team up to *reduce labor costs* by eliminating a time consuming assembly step and *to improve performance* by doing away with an embrittlement that was encountered during the development and testing period.

Users of General Plate Products benefit from our unique ability to design and manufacture clad metals for their specific needs. Complete technical literature and samples of all our products will be sent to you. Competent field engineers are available to review your old or new designs with you and provide design assistance. Write for Catalog GP-1B.

*Reg. T.M. of Proctor-Silex Corp.



3. Clad High Conductivity Spring Metal — The original torsion member was made of two-piece construction. Using General Plate stainless steel clad copper, reliable spring characteristics and high conductivity are now obtained in a single piece which is easily welded to the stainless case.

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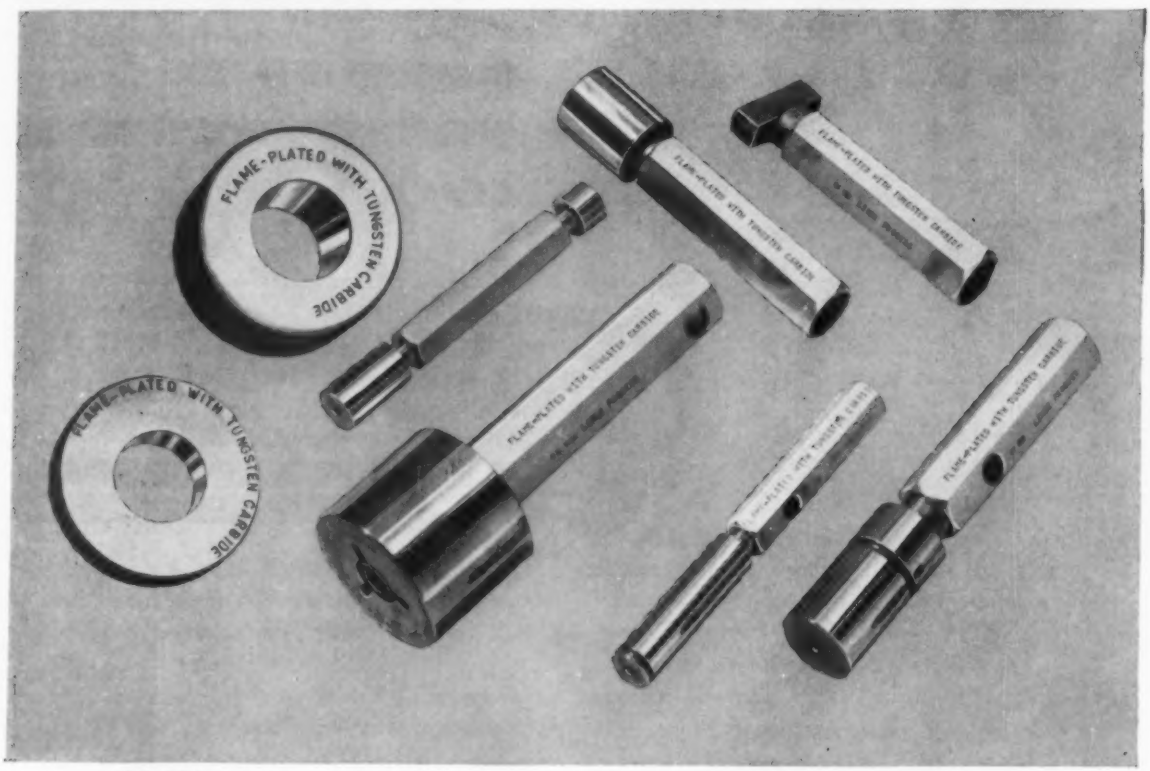
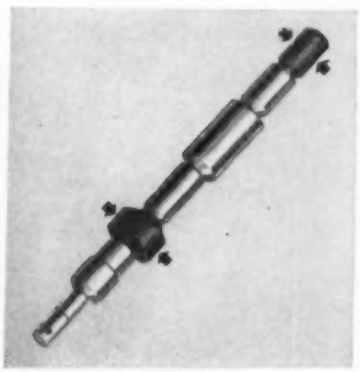
PRECISION PARTS GET TODAY'S LINDE's FLAME-



GAGES—Superior wear resistance and other unique cost-saving advantages are exhibited by plug, ring, air, and specialty gages treated by LINDE's Flame-Plating. For example, Flame-Plated plug gages outwear solid carbide plug gages 3-to-1, and hard chrome-plated gages 20-to-1.

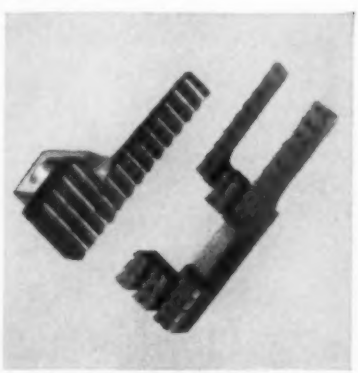


AIRCRAFT VALVES

Bearing surfaces of hot air valves used in the bleed air system of Lockheed's F-104A Starfighter must meet extreme conditions of wear and abrasion, also conditions of high unit loading and temperature extremes. Flame-Plating these surfaces with tungsten carbide solves the problem.

ALUMINUM ROCKER ARMS

One side of the "fin" of this important item in an aircraft engine heater mechanism actuates a lever and is subjected to severe wear. Before Flame-Plating, it lasted from 100 to 300 hours. Coating the wearing surface with tungsten carbide boosted service life to more than 1000 hours.



SEWING MACHINE FEED DOGS

LINDE's Flame-Plating has increased by more than six times the service life of the movable, serrated part that pushes material through the sewing machine. In this application, a .002-in. coating of tungsten carbide in as-coated condition provides both long wear and dependable gripping.

LONGEST SERVICE LIFE with PLATING

Gages and other components achieve remarkable resistance to wear when coated with tungsten carbide and other materials by LINDE's 6,000-degree, supersonic "weld-on" process . . .

NOW—many of the profit-consuming problems of metal wear and machine down-time have been eliminated.

With LINDE's Flame-Plating, gages, spindles, bushings, seals, mandrils, dies, core rods and other precision parts and components retain their precision and close tolerances for the *longest* period of time—under the toughest conditions of abrasion, erosion, corrosion, and high-temperature wear.

LINDE's exclusive service coats base metals with particles of ultra-hard materials, such as tungsten carbide and aluminum oxide—heated to plasticity by 6,000 degrees F. inside the Flame-Plating gun and then successively "fired" at 2,500 fps at the "target area."

The result is a tenacious, "welded-on" coating of approximately 125 microinches rms, which can be finished to the desired microinches rms.

NO WARPAGE—NO METALLURGICAL CHANGES

Despite the 6,000-degree temperature within the Flame-Plating gun, the temperature of the precision part or product being coated remains below 250 degrees F. This feature eliminates distortion and changes in the properties of base metals. Other features include low coefficient of friction and porosity of less than 1 per cent.

Wherever *continuing* precision and *optimum* wear are important factors, LINDE's revolutionary Flame-Plating gives amazingly longer service life . . . reduces production rejects . . . increases salvage value.

Find out how this coating service offered by the Linde Company can save on operating costs, make a good product even better, and improve over-all reliability. LINDE will provide a complete engineering analysis. List your possible applications in the coupon on the right and mail today for complete information.

TYPICAL FLAME-PLATING APPLICATIONS

BEARINGS—sleeve, roller, gas
BLADES—aircraft turbine; doctor blades for papermaking
BLOCKS—anvil
BUSHINGS—ball piston pump
CHUCKS—seaming
CUTLERY—household
CUTTING, INDUSTRIAL—rubber, plastic, skiving knives, foods, paper, slitter knives, chipper knives, discontinuous chip-abrasive materials
DIES, TOOLING—cold-forming; coring punches, core rods, sizing punches, capstans
DOGS—sewing machine feed; gripping dogs
DRILLS—paper, acoustical tile, twist
GAGES—plug, ring, air
GUIDES—wire, textile, machine
HYDRAULICS—pistons, liners, valve plates, wobble plates, metering valves, servo valves, slippers
MANDRILS—wire-forming
PARTS—sintered
PISTON RINGS
PLATES—valve, wear
SEALS—turbine engine, pump
SURGICAL—needle holders and shears
VALVES—aircraft

M1-11

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UNION CARBIDE

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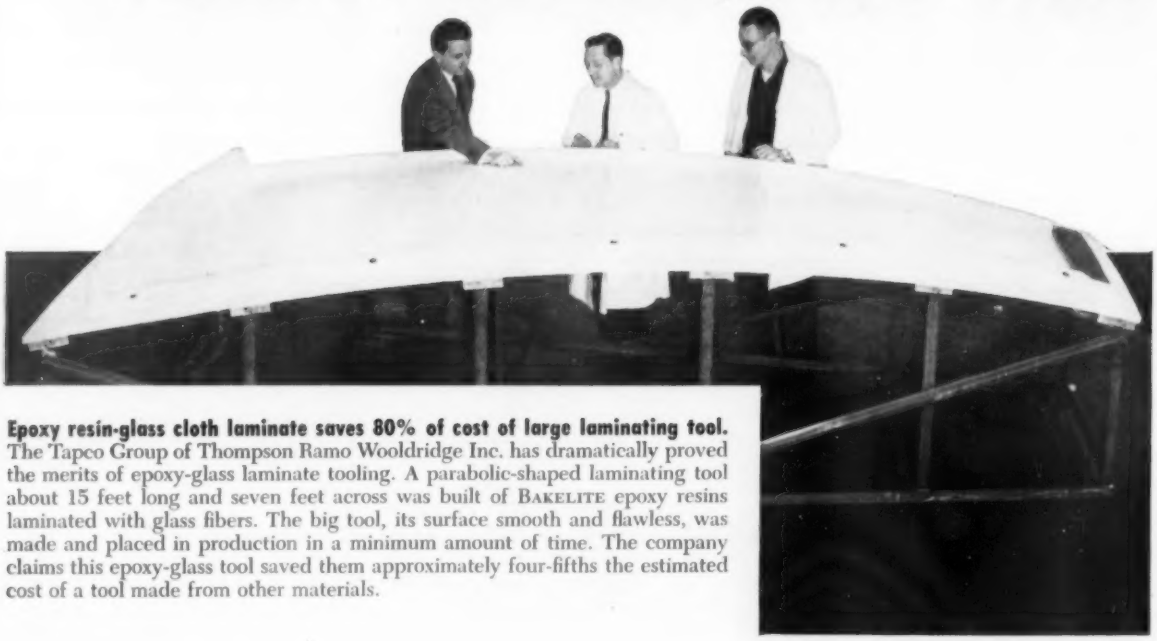
Epoxy resin-glass fiber helicopter part is stronger, lasts 5 times longer than metal. Air deflecting contravanes, mounted directly on the engines of Sikorsky S-58 helicopters, are subjected to engine vibration. Formerly made from metal, such contravanes became inoperative after about 3 million cycles in a test machine. Now, contravanes made of glass fiber impregnated with BAKELITE Brand epoxy resin are being used in this important assembly. Manufactured by the Fibremold Division, Hampden Brass and Aluminum Company, the epoxy-glass combination has exceptional ability to dampen vibration and resist fatigue. Tests show no failures after 15 million cycles! As an extra bonus, the epoxy-glass part cuts weight 11½ per cent.

TO GAIN STRENGTH, REDUCE WEIGHT, SAVE TIME



Epoxy resin-glass cloth laminate saves 80% of cost of large laminating tool. The Tapco Group of Thompson Ramo Wooldridge Inc. has dramatically proved the merits of epoxy-glass laminate tooling. A parabolic-shaped laminating tool about 15 feet long and seven feet across was built of BAKELITE epoxy resins laminated with glass fibers. The big tool, its surface smooth and flawless, was made and placed in production in a minimum amount of time. The company claims this epoxy-glass tool saved them approximately four-fifths the estimated cost of a tool made from other materials.

Epoxy-glass "spinners" dampen vibration, maintain strength despite alternate icing and heating. Predicted long, reliable service life is one of the outstanding features of epoxy resin-glass cloth propeller "spinners" now being used on Grumman "Mohawk" airplanes. The epoxy-glass cloth "spinners" which incorporate de-icers for the aircraft's propellers possess excellent tensile strength and fatigue resistance—very important properties for a part that is subjected to severe vibration. The wire heating elements, that are laminated right in with the glass cloth and impregnated with BAKELITE Brand epoxy resin-based compound, have excellent electrical insulation. The strength-to-weight ratio of the "spinner" is high. In addition, the manufacturer, Fibremold Division, Hampden Brass & Aluminum Company, reports production costs are substantially lower.

...DESIGN IT WITH EASY-TO-FABRICATE EPOXIES

New and practical applications for epoxy resins—often in combination with other materials, such as glass fiber and metal—are being introduced by ingenious designers in many fields. No other resin commercially available offers so many advantages: exceptional strength—stronger than other plastics—even under wide temperature ranges . . . excellent resistance to most chemicals, water and weather . . . ease of fabrication that saves untold hours of production time and costs. Some of the newer applications for epoxy resins include filament winding, electrical encapsulation and embedment, and fabrication of large storage vessels and containers.

For more information about BAKELITE Brand plastics—epoxies, polyethylenes, phenolics, styrenes, and vinyls—mail the coupon today. See Sweet's Product Design File, section 2a/ui, for a list of properties.

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UNION CARBIDE

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Please send me information on BAKELITE resins and suggested applications. I am especially interested in

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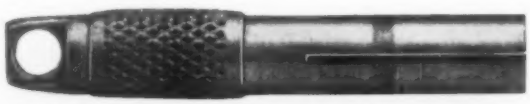
BERYLCO INSPIRES NEW DESIGN THINKING



3½ times actual size

Electrical connector of beryllium copper rod: By selecting a Berylco alloy, the designer met requirements for high conductivity, corrosion resistance, high contact force, and excellent resistance to creep. The connector also has enough yield strength to permit mis-alignment of the mating connector without loss of electrical contact. It is usable up to 300°F. Lead-in wires can be soft-soldered to the connector.

Bearing race cast from beryllium copper ingot: The choice of Berylco alloy on this investment casting was easily made because its high fluidity provides good surface, close tolerances, excellent detail and the ability to cast thin sections. When added to the advantages of the alloy itself, like high strength and good wear resistance, it becomes easy to see why beryllium copper is being used more and more in several casting methods.

New advances in critical parts performance now possible The ever-widening and increasingly successful use of Berylco beryllium copper alloys is opening a whole new area of design thinking on parts. The list of attributes in this amazing alloy reads like a Who's Who of famous performance characteristics: good conductivity, high fatigue strength, non-magnetic, high strength, unusual wear resistance, resistance to anelastic behavior, good corrosion resistance, excellent hardness, wide operating temperature range. Find out what these characteristics can mean to the parts you are now working on. Write for our latest BERYLLIUM COPPER BULLETIN. To assist you further, an experienced, knowledgeable staff of field and mill technicians stand ready to translate design possibilities into performance realities.

Bellows of beryllium copper strip: The design engineer on this part knows a Berylco alloy is a fine choice because its low modulus of elasticity (approx. 18.5×10^6) gives greater deflection for a given pressure change than other high strength alloys. And it has good fatigue strength with a yield strength that gives excellent usable movement range.

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THE BERYLLIUM CORPORATION

Reading, Pennsylvania

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ENGINEERING & DESIGN

...AT A GLANCE

9% nickel steel can be used at liquid nitrogen temperatures in the quenched and tempered condition, a recent demonstration proves. It was put on by International Nickel Co., Inc., United States Steel Corp. and Chicago Bridge & Iron Co. Although most codes require that structures be stress relieved after fabrication, the public test showed that a welded 9% nickel steel tank cooled to –320 F withstood a series of impact blows ranging up to 82,500 ft-lb.

A better understanding of the properties of paint, such as adhesion, weatherability and appearance, may result from a new test method in which the chemical composition of the very surface of a paint coat can be analyzed. The surface is lightly abraded with potassium bromide powder. The powder, contaminated with surface particles, is collected and pressed into a disk which yields an infrared spectrum of the film surface. The spectrum shows that film surfaces differ greatly from bulk film. For example, in a paint containing silicone oil, the silicone oil concentrates at the surface—over the paint pigment.

Source: W. Johnson, E. I. du Pont de Nemours & Co., Inc., Marshall Laboratory, 3500 Grays Ferry Ave., Philadelphia 46.

Composite turbine disks consisting of an austenitic steel rim welded to a pearlitic steel hub show several advantages over solid austenitic steel disks, according to recent Russian research. They are less costly and show better stress distribution.

Titanium with small additions of antimony is harder and stronger than unalloyed titanium, recent research shows. Adding 5% antimony increases yield strength about 10% without sacrificing ductility. Tests show that antimony forms extensive solid solutions with titanium.

Source: Rpt. No. RI 5586, U. S. Bureau of Mines, Dept. of the Interior, Washington 25, D. C.

Strain gages or transducers to measure force, acceleration, vibration and other forms of physical stress can be made successfully with silicon semiconductors as sensing elements, according to recent research. Low impedance of the silicon whisker, combined with its high output, is said to result in a superior signal-to-noise ratio. A device made of a silicon whisker provides a gage factor of 130 compared to 5 for devices made of metal, research shows.

Source: W. V. Wright, Electro-Optical Systems, Inc., 125 N. Vinedo Ave., Pasadena, Calif.

Creep-rupture properties of carbon and alloy steels used in oil refinery piping are not appreciably changed after 83,000 hr exposure to temperatures up to 1000 F, a recent producer's study shows. Over 138 different steels were tested.

Source: United States Steel Corp., National Tube Div., 525 Wm. Penn Pl., Pittsburgh 30.

Best cooling medium for electronic equipment used in ballistic missiles is a water heat sink which absorbs heat by evaporation and heating of the resultant gas. The missiles operate at velocities from Mach 8.0 to 20.0 at altitudes of 80,000 to 200,000 ft. Studies show that ammonia, hydrogen and methyl alcohol are also good heat sinks where the high freezing or boiling point of water might be a problem.

Source: Rpt. No. PB 161484, Office of Technical Services, Dept. of Commerce, Washington 25, D. C.

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Short-Time, Rapid-Heating Tests for Aerospace Materials

Newer testing methods featuring rapid heating are being developed to furnish data needed in designing missiles and supersonic aircraft.

by Ward F. Simmons, *Chief, Div. of High Temperature Metals Research, Battelle Memorial Institute*

■ The aerodynamic heating encountered by aircraft and missiles at supersonic speeds has already outmoded tests conventionally used to determine short-time tensile strength and creep of metals and alloys. Even better high temperature tests and materials performance will be needed for imminent high speed atmospheric flights where skin temperatures may exceed 2000 F and for reentry vehicles which may be exposed briefly to temperatures of 6000 F or more.

In addition to temperature, other interrelated factors of great importance must be considered when designing for high-speed flight. These are stress, allowable strain and time. It was the need for very-short-time tensile and creep data (for intervals between 3 sec and 100 min) that dictated the development of newer testing methods incorporating high speed heating and loading.

Choice of the best high temperature testing method is governed by six specific considerations:

1. Purpose of the test and type of data desired.
2. Minimum precision required.
3. Speed of heating and loading.
4. Size of specimen or structure to be tested.
5. Whether a special protective atmosphere or vacuum is required.
6. Cost.

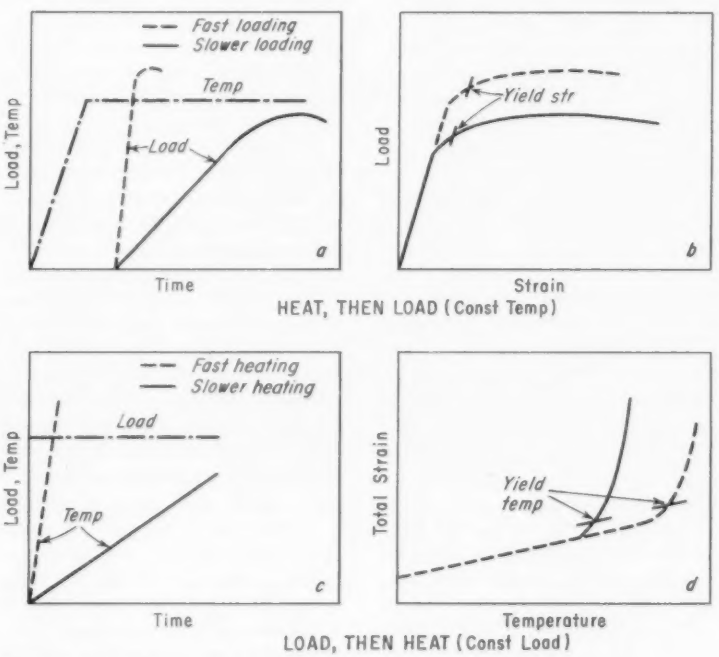
The method selected should, of course, yield the required data, but unnecessary data should not be determined and unnecessary precision in measurement and control should not be required.

Testing methods simulate rapid heating, loading

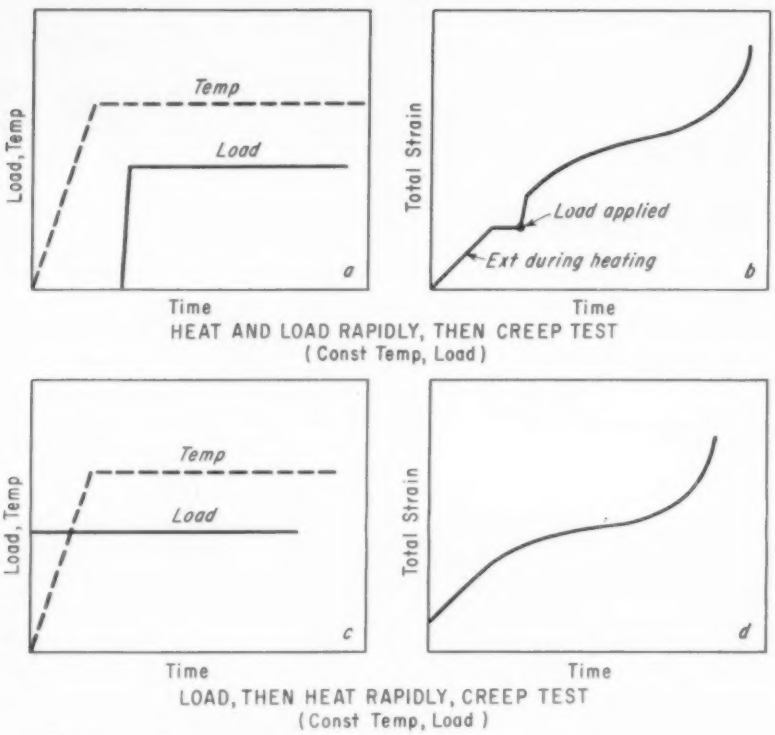
Most commercial alloys are not structurally stable at high temperatures. This instability is time-dependent and involves such metallurgical changes as stress relief, recrystallization, oxidation, solid-solution hardening, and precipitation effects.

Since some missile and rocket applications may involve load times as short as a few minutes or even seconds, knowledge of very-short-time strength characteristics is vital to efficient design and may permit the use of lower alloy materials. For example, short-time creep data at 1200 F indicate that, for times of 1 and 10 min under load, heat treated SAE 4130 is superior to low carbon 18:8 chromium-nickel austenitic steel, but that after 100 min, the low alloy steel has lost its advantage.

Fig 1 shows schematic diagrams of the two commonly used types of high temperature *tensile* tests. The test described in Fig 1a and



1 ***Two tensile tests*** *are generalized here.*



2 ***Generalized creep tests.***

1b is made by heating the specimen rapidly to the test temperature and then loading either rapidly or at conventional rates. Fig 1c and 1d show the test where the specimen is loaded cold and then rapidly heated to failure.

Rapid heating *creep* tests are shown schematically in Fig 2. These are similar to the tensile tests except that after rapid heating to the desired temperature, and possibly rapid loading (1a), both temperature and load are usually held constant. However, it is possible with some of the newer equipment to program load, temperature and time to simulate the conditions to be encountered during the proposed mission of a vehicle.

Specimen design

Specimens for very-short-time tension and short-time creep testing after rapid heating must fulfill several requirements:

First, they must be representative of the material being investigated. Thus, specimens should be taken from material in the same forms and conditions as those in which it will be used. This is a basic requirement of good testing practice, but it is especially important in tests of very short duration.

Second, specimens must be adapted to meet the requirements of temperature control and uniformity, and of various rates of heating and straining.

Gage length dimensions should follow certain prescribed standards to permit correlation of short-time data with those obtained in conventional tests, as well as short-time tests performed in other laboratories. For round specimens the preferred ratio of gage length to diameter is a minimum of 4. For strip specimens a gage width of 1/2 in. and length of 2 in. are preferred.

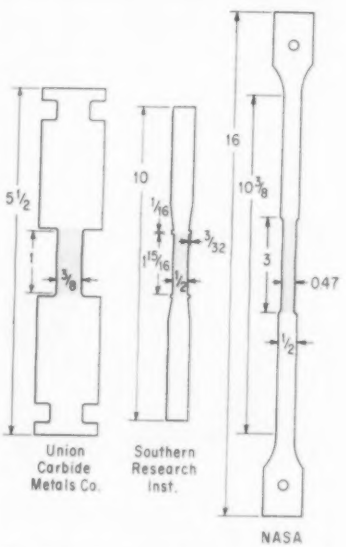
When smaller specimens must be used, the gage length should be four times the width (ASTM Recommended Practices E150-59T and E151-59T, Sept 15, '59).

Three typical specimen designs used for rapid heating tests of sheet materials are shown in Fig 3 on the previous page.

The effect of specimen design on temperature distribution within the gage length is particularly critical when resistance heating is used, but it tends to be less critical the faster the heating rate. The left specimen in Fig 3 would have a reasonably uniform temperature only in the center of the reduced section. An effective gage length for this specimen is 0.27 in.; it limits deviation from mean temperature to ± 14 F.

At Battelle, when designing a 2-in. gage length specimen for rapid heating tests using resistance heating, it was found that the length of reduced section had to be about three times the gage length to heat the gage length uniformly. If heating is uniform there will be little difficulty in maintaining a stable test temperature.

The method to be used for measuring strain must be kept in mind when designing the specimen. The preferred method is to attach the extensometer directly



3 ***Typical specimens*** *used in rapid heating tests of sheet materials. Temperature and deformation measurements are made in the narrow central necks (shaded).*

to the gage length of the specimen. When this is not done, adequate calibrations must be made to compensate for the strain that will occur outside the gage length. This strain will vary with different materials and temperatures. Care must be exercised that the extensometer clamps do not act as a heat sink. Fig 4 shows a test specimen, with a spring-type clip-on extensometer in place.

Design of the grip ends should take into account the type of test, the method and rate of loading, alignment problems and, in the case of resistance heating, the electrical contacts.

Four methods used for rapid heating

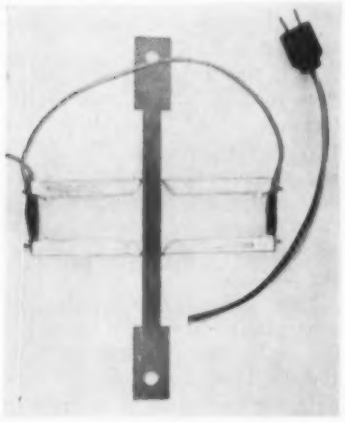
Several methods of rapid heating are being used, including resistance, radiant, hot fluid and induction heating.

Resistance heating is probably the most popular method because of its simplicity and ease of control, and because there is no surrounding furnace to interfere with strain measurements. However, any discontinuity in the specimen gage length, such as necking or a crack, increases resistance and produces a local hot spot. To avoid such hot spots, some experimenters use a dual heating system for rapid heating creep tests: the specimen is heated to the test temperature by resistance and then maintained at the desired gage-length temperature by radiant heat. Others discontinue the tests prior to necking, or make a correction to the observed rupture time.

Radiant heating may be applied to specimens by quickly enclosing them in split furnaces already heated to the test temperature.

Hot fluid analogy provides a simple and inexpensive means to simulate in the laboratory the high heat fluxes experienced by high speed aircraft. For example, the heating rate caused by an air flow of 2200 fps over a body can be obtained with oil moving over the same body at a velocity of 14 fps. Use of molten salts instead of oil makes this heating technique useful to temperatures of about 1000 F.

Induction heating with a high-frequency induction coil surrounding the specimen has the advantage that the necked-down region of the loaded specimen does not overheat as fracture is approached. Disadvantages are 1) that the heating coil prevents the use of extensometers attached to the gage length, and 2) that radio-frequency current has to be filtered out of the thermocouple circuit.



4 Sheet specimen *with a spring extensometer clipped to the small projections at each end of the gage length. A thermocouple is also attached to the gage length.*

Temperature measurement

Measurement of specimen temperature is a major problem in rapid-heating testing because the response of the temperature-sensing element must be both accurate and instantaneous. In very-high-speed heating, a lag of a fraction of a second may result in serious overshooting of the test temperature, or cause objectionable thermal cycling during holding at the test temperature.

Thermocouples have found the widest application in rapid-heating tests because of their accuracy, low cost and ready availability. Radiation pyrometers, measuring either total or infrared radiation, are used to a lesser extent. No matter which method is used there are serious difficulties to overcome.

Thermocouples must produce a satisfactory thermal emf over the testing temperature range, and they must withstand the combination of test temperature and atmosphere with negligible deterioration during the test. The smallest possible gage wire should be used to minimize heat conduction from the specimen surface and to reduce lag. No. 36-gage Chromel-Alumel thermocouples are generally used.

The method of attaching thermocouples to the test specimen is very important. The method finally adopted at Battelle after considerable experimentation on sheet materials was to sandwich the flattened beads of 36-gage thermocouples between duplicate test specimens which were then tested as a single specimen. Since the thermocouple beads and a short length of lead wire were essentially buried in the specimen, inaccuracy from radiation or conduction losses was virtually eliminated.

Because this method unfortunately cannot be applied to bar specimens, techniques for spot welding thermocouple wires to the surface of the specimen had to be worked out. To correct for radiation or conduction errors, spot welded thermocouples are calibrated against similar thermocouples sandwiched between two specimens. Conduction losses can be minimized by keeping the thermocouple wire adjacent to the hot junction as close to the hot specimen as possible during a test.

Another problem to be solved when thermocouple wires are welded to resistance heated specimens is that of emf pickup from the heating current, which results from improper thermocouple alignment. This pickup appears as "60-cycle flutter" when a.c. heating is used and may not only yield false temperature indications, but even burn out the galvanometer coils of potentiometers. Pickup from d.c. heating is more difficult to detect, but can be recognized readily by heating a specimen to some intermediate temperature, then cutting off the

heating power. If emf pickup is present, there will be a discontinuity in the time-temperature trace at the instant of power cutoff. Some investigators use this method to detect imperfect thermocouple alignment; they then re-position and re-weld one of the two wires until alignment is satisfactory.

Radiation pyrometers offer certain advantages over thermocouples: The pyrometer is not in contact with the specimen, thus eliminating the time involved in positioning and welding the thermocouple. Also, radiation pyrometers obviate such problems as emf pickup and local specimen damage which may result from welding.

However, radiation pyrometers also have certain disadvantages. The indicated temperature is dependent not only upon the temperature of the surface, but upon the material and the nature of the surface. Furthermore, under rapid heating the emissivity of the surface may change with the course of the test, depending upon the progress of surface oxidation. The problem of changing emissivity has been minimized by coating the target area of the specimen with a suspension of a fine iron oxide powder. This coating produces a rough surface of high emissivity which retains its characteristics during the course of the tests. Such a system is calibrated by observing the incipient melting of *thin* wires of noble metals or their alloys spot welded to the central portion of the specimen surface.

The output from either thermocouples or radiation pyrometers is fed into a variety of recorders and controllers, the nature of which is determined by the heating equipment, the heating rate, and the type and duration of the test. Rapid response is a primary requirement of all of these instruments. In very-high-speed heating, it is common practice to photograph the temperature trace on the screen of an oscilloscope; at lower heating rates, oscillographs or high speed recorders are employed quite often.

Three loading methods

In general, three types of loading are used in making tensile or creep tests after rapid heating: dead-weight lever-arm loading, screw-driven mechanical loading, and hydraulic loading.

Loading requirements for the rapid heating tensile test, Fig 1c, and the rapid heating creep test, Fig 2c, are very simple, and any loading device that will apply a constant axial load with no twisting or bending can be used. A conventional lever-arm creep machine is often used for this purpose.

The tensile test after rapid heating, Fig 1a, can be made in a screw driven testing machine if normal loading rates are used, but if rapid loading is desired special loading devices such as a high speed mechanical or hydraulic machine must be used.

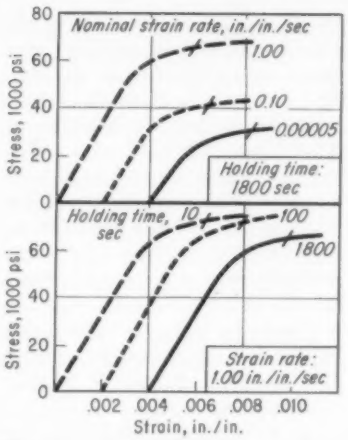
Strain measurement

The slow heating rates and the soaking periods normally used in conventional tensile and creep testing are usually sufficient to bring about thermal equilibrium in the extensometer system. In rapid heating tests, however, the extensometer system must be insensitive to temperature changes or it must be kept at a constant temperature. Also, it must be lightweight and have a fast response.

To meet ASTM Recommended Practices E150 and E151, the extensometer must be Class B-2 (max error 0.0002) or better for creep tests, and for tensile strains of up to 0.6% offset. Above that, Class C (max error 0.001) or better extensometers must be used.

The output of the extensometer must be such that it can be recorded automatically. Two types of extensometers are in general use: the linear differential transformer type, and the clip-on spring-type extensometer which uses SR-4 strain gages.

Devices for amplifying and recording the strain in rapid heating tests are similar to those used in conventional testing except for faster response. As in recording temperature, high speed recorders, oscillographs, and photographic records of oscilloscope screens are used.



5 Stress-strain *curves at different strain rates and constant holding time (top), and at fixed strain rate and various holding times (bottom). Test corresponds to Fig 1a and 1b. Material: 17-7PH stainless steel sheet. Temperature: 1200 F. Heating rate: 120°F/sec.* (Southern Research Inst.)

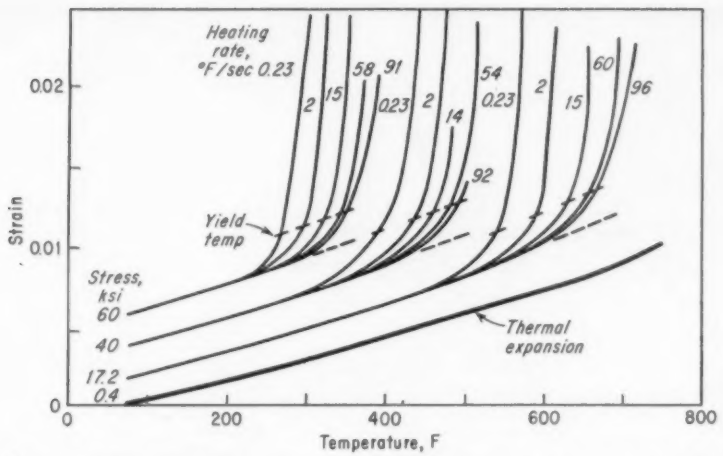
Presentation of data

The selection of materials to be used at high temperatures and stresses is based on the requirement that no part fail because of excessive strain. All designs require that fracture must not occur within the design life. Most designs limit strain to no more than 1% and some require as little as 0.1%.

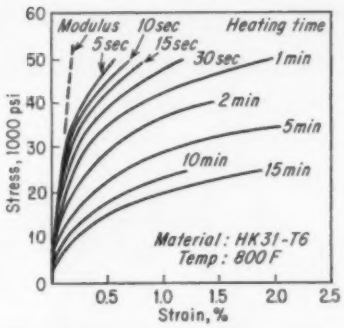
It is the metallurgist's job to develop new alloys and to determine their suitability for various applications. His task is less difficult if the design engineer states his specific materials requirements and indicates how he would like the data to be presented.

The following examples of presentation have been chosen to illustrate the plotting methods thought to be most useful. Actual data for materials of interest to aircraft materials engineers have been used.

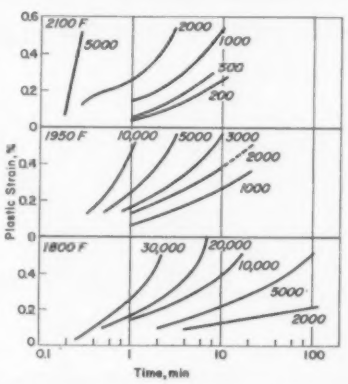
Fig 5 shows tensile data from tests of 17-7PH stainless steel



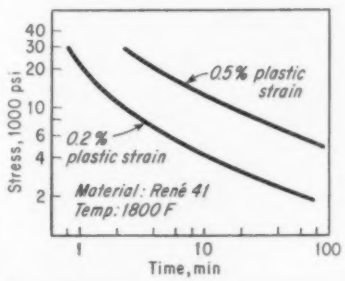
6 Strain-temperature *curves show the sensitivity of differently stressed specimens to various heating rates. Instead of conventional yield strengths (Fig 5) these tests provide yield temperatures. Material: 7075-T6 aluminum sheet.* (NASA)



7 Isochronous stress - strain *curves show elastic and plastic strain vs stress for various heating times.* (Dow Metal Products Co.)



8 Time-strain *curves for different stresses (psi) where loading precedes heating. Material: René 41 nickel alloy sheet.* (General Electric Co.)



9 Stress-time *design curves for two plastic strains at a fixed temperature.* (General Electric Co.)

after rapid heating (see Fig 1a and 1b). These are conventional stress-strain curves showing the effect of strain rate.

The rapid heating tensile test (Fig 1c and 1d) is extremely useful because it can be made easily at temperatures too high for conventional tensile equipment. It differs from the usual tension test in that load, instead of temperature, is held constant and the specimen is heated at a uniform rate to failure. Fig 6 shows strain-temperature curves for 7075-T6 aluminum alloy for various stresses and heating rates. Note that whereas the constant-temperature type of tension test is sensitive to strain rate, this constant-load test is sensitive to heating rate. Also, instead of the conventional yield strength, this test gives a *yield temperature* which can be correlated with yield strength data.

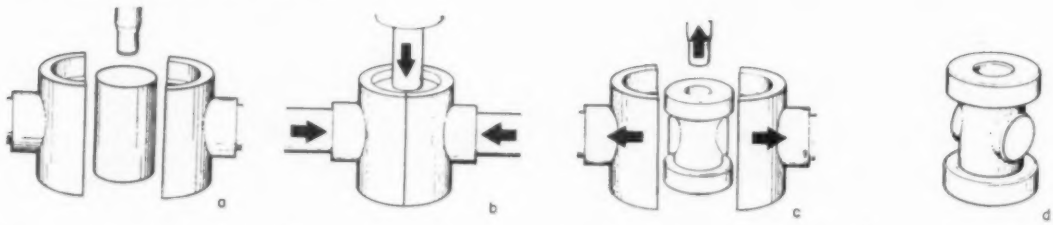
A creep test of the type described in Fig 2a and 2b gives strain as a function of time for a given stress and temperature. Usually a series of creep tests will be made at different stresses at any given temperature, and a family of strain-time curves plotted. There are several methods of organizing and plotting creep information from these primary creep data curves. One of the best for short-time creep is the use of isochronous (uniform time interval) stress-strain curves; these relate stress and strain for various times at a given temperature. Fig 7 shows isochronous stress-strain curves for cast HK31-T6 magnesium-thorium alloy at 800 F. This graph shows elastic strain to the left of the modulus line and plastic strain to the right.

Short-time creep tests where load is applied prior to heating (see Fig 2c and 2d) must be handled a little differently. Usually the base line for the strain measurements is room temperature and no load. Total elastic, or creep strain is reported. If only plastic strain or creep strain is considered, the total strain must be corrected for 1) initial elastic strain, 2) thermal expansion, and 3) strain due to change in elastic modulus with increasing temperature under a fixed load.

Fig 8 shows the primary data curves (Fig 2d corrected to plastic strain) of time vs plastic strain for René 41 alloy sheet at three temperatures.

The design curves in Fig 9 were constructed by cross plotting the creep data at 0.2 and 0.5% plastic strain for René 41 sheet at 1800 F. They show the relationship between stress and time for various plastic strains at a given temperature, but they do not give as complete a picture as the curves in Fig 7.

VERTICAL FORGING



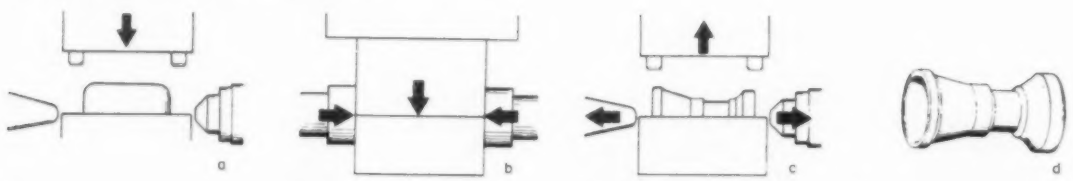
a. *Side dies are closed on the billet.*

b. *Vertical ram carrying the required shape enters the closed die and completes forging.*

c. *Side dies are opened, ram is withdrawn, and forging is extracted.*

d. *Forging has multiple parting planes, no flash, and no draft.*

HORIZONTAL FORGING



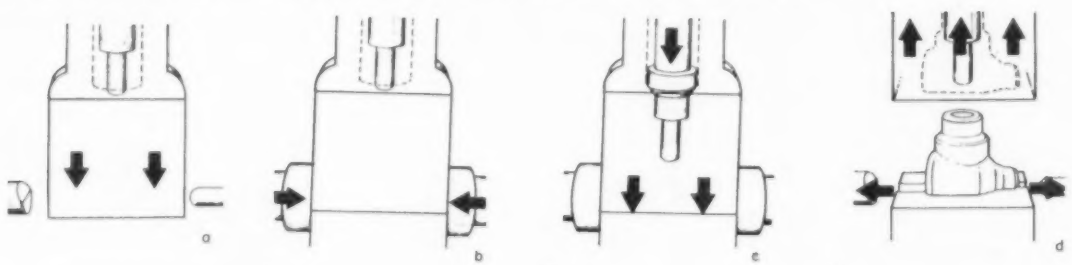
a. *Main die is closed on billet.*

b. *Side rams enter die and complete the forging.*

c. *Main die is opened, side rams are withdrawn, and forging is extracted*

d. *Forging in this case has double conical extrusions and no flash.*

COMBINED VERTICAL AND HORIZONTAL FORGING



a. *Billet is placed in die and main die is closed.*

b. *Side rams enter the die.*

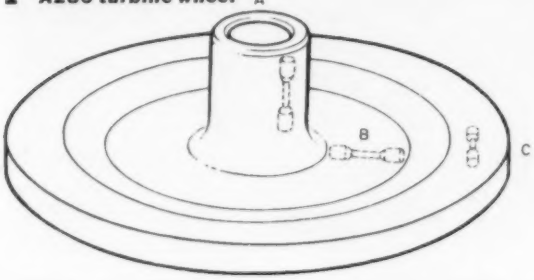
c. *Vertical internal punch carrying required shape enters die and completes forging.*

d. *Rams and punches are withdrawn, and forging having vertical and horizontal cavities is extracted.*

This Is Split Die Forging

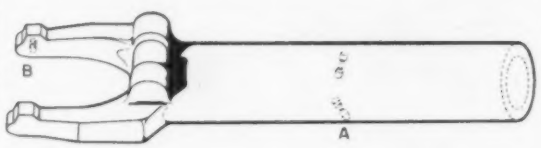
It produces intricate, no-draft parts

1 ***A286 turbine wheel***



Code	Location	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, %	Red. of Area, %
A	Hub, longitudinal	158	117	22.2	40.0
B	Web, radial	159	116	21.3	40.0
C	Rim, tangential	162	117	20.3	39.7

2 ***AMS 6407 landing gear***



Code	Location	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, %	Red. of Area, %
A	Tube, transverse	236	203	12.7	45.1
B	Fork, transverse	233	205	10.6	31.9

Development of split die forging techniques for high strength alloys makes it possible to produce no-draft forged parts having multiple cavities and unusual contours. Flash is eliminated because the forging is totally enclosed. Parts are produced in a single set of dies with one operation. The various forging combinations that can be employed are shown above.

The process is used by Cameron Iron Works, Houston, Tex., to produce jet engine components, nuclear reactor parts, missile components, and a variety of other complex parts. The forgings range from 8 to 13,000 lb in weight. Some typical parts are shown in the accompanying photographs.

Materials

Below are listed the materials that have already been forged successfully.

Alloy Steels: 4130, 4132, 4140, ASTM A182F11, ASTM A182F22, 4350, AMS6407, 6030, 4135, 4355, AMS6427

Superalloys: A286, René 41, Waspalloy, AM355

High Strength Steels: Tricent

Stainless Steels: 304, 310, 316, 410

Other: Incoloy 901, Haynes Stellite 25, Chromalloy, Zircaloy-2, titanium 6Al-4V, arc cast molybdenum

The wide range of compositions given here is an indication that any material that can be forged can be used in the process.

Properties, tolerances

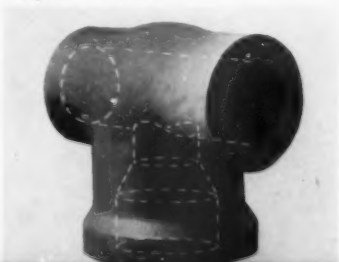
Internal working of the metal in these forging operations breaks up segregated material in the center of the billets. As a result, uniform properties are obtained from surface to center of the part, as indicated in Fig 1 and 2. The properties of the two materials are uniform regardless of the location from which the test specimen has been taken.

Tolerances achieved on the forgings cannot be reduced to a general set of figures. The forging process is often developed as an empirical design to fit a particular component which might be difficult to produce by standard methods. On this basis, factors such as achievement of component geometry, development of high and uniform mechanical properties and conservation of material overbalance the need for standard stock tolerances.

Jet engine turbine shaft
Material: A286 Dia.: 23 in.
Length: 34 in. Weight: 304 lb

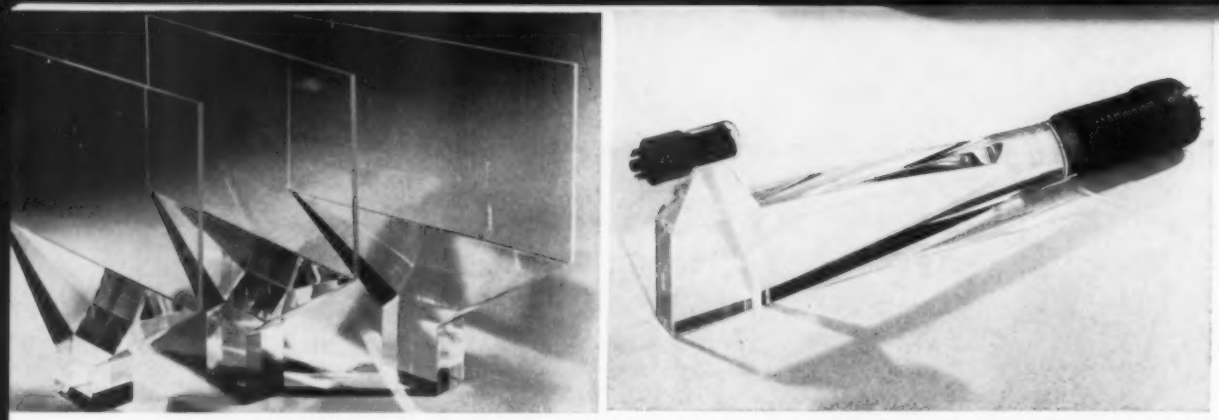
Lift plug (circled) and other valve parts
Material: Type 410 stainless steel
Height: 19⅝ in. Width: 6 in.
Weight: 40 lb

14-in. gate valve for AEC
Material: Type 304 stainless steel
Height: 30 in. Length: 31 in.
Weight: 2000 lb



Turbine steam chest
Material: ASTM A182F11
Length: 50 in. Dia: 20 in.
Height: 26 in. Weight: 3400 lb

All photos
Cameron
Iron Works



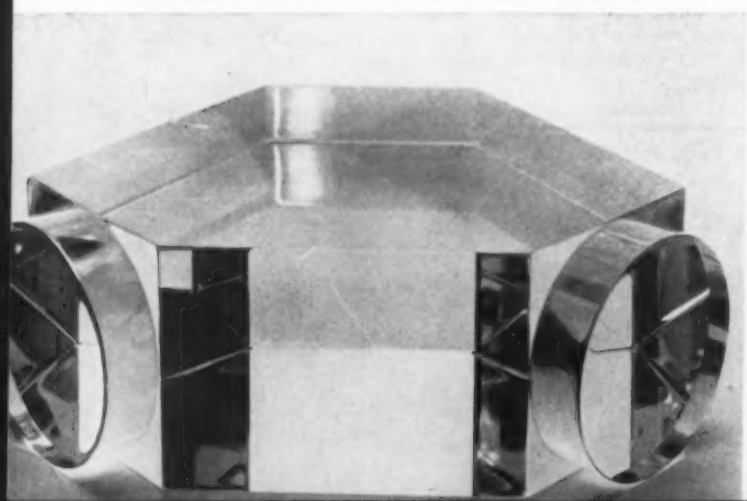
Polystyrene scintillators. *These polystyrene (97.5% styrene monomer plus suitable additives) scintillator plates are used to detect and count nuclear particles accelerated to very high velocities. The plates of the scintillator at the left measure 6 x 8 x 1/4 in. and are cemented to an acrylic light pipe to carry visible flashes of light to a photomultiplier tube (not shown). The scintillator at the right has a different configuration and incorporates acrylic light pipes and photomultiplier tubes at each end.*

Plastics for Atom Smashers

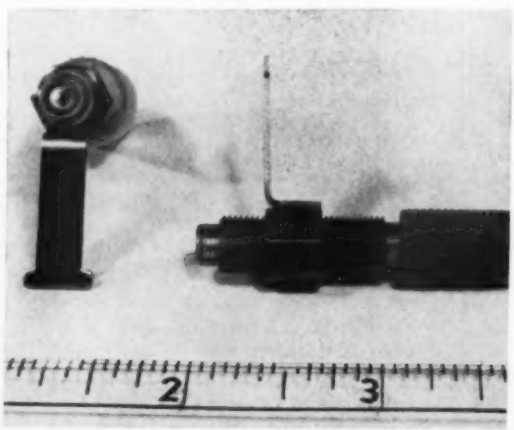
A high energy nuclear accelerator, together with its supporting apparatus, is a group of highly complex instruments which present unusual materials selection problems. The parts shown here illustrate why plastics have played an indispensable role in the design of today's powerful atom smashers.

by James O. Turner, *Lawrence Radiation Laboratory, University of California*

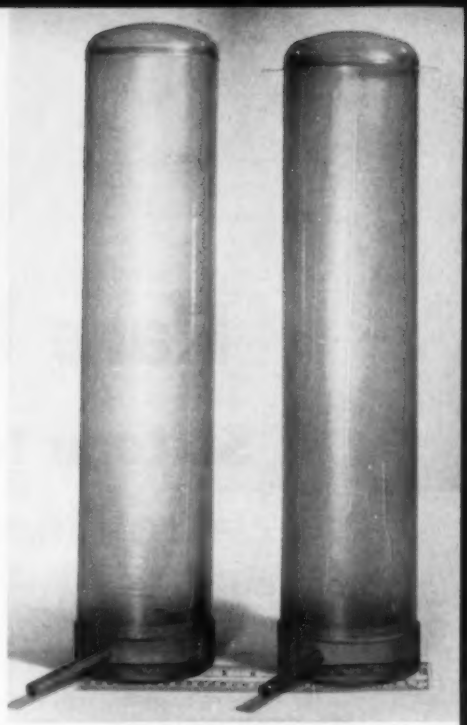
Acrylic Cherenkov radiator. *This component is based on the principle that when a charged particle traveling at a speed very near the speed of light in a vacuum is fired into a dense medium, its velocity will be above the speed of light* for that medium. *If the material is transparent, it will give off a shock wave of visible light known as a "Cherenkov" radiation. In the acrylic radiator shown, the beam's direction is toward the viewer, and the two circular bosses are for attachment of photomultiplier tubes.*



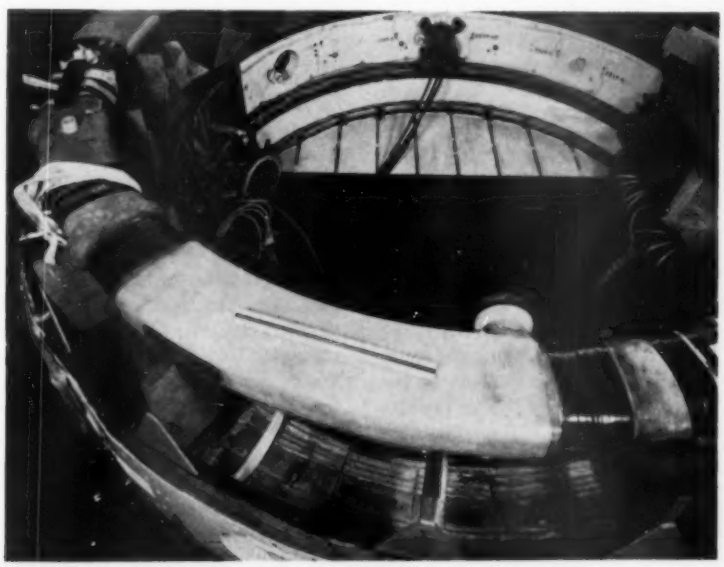
Polycarbonate thumb screw. *This screw is used in making precise adjustments. It is made of polycarbonate resin because of the material's exceptionally good dimensional fidelity and impact strength.*



Allyl reflecting lenses. *The designers needed a highly specialized retrodirective reflector for a liquid hydrogen bubble chamber that would reflect light very accurately, would not produce any reflected images, and would withstand submersion in liquid hydrogen at —450 F. Machined and polished clear plastics lenses in the configuration shown proved to be the best material (the lenses are actually clear although they appear opaque in the photo.) A point source of light is placed at the center of curvature of the long axial curve. The light entering the surface of the lens is brought to a line focus on the bottom surface which is aluminized. The metallic coating reflects the light directly back on itself toward the source, thus providing illumination of the bubbles from below.*

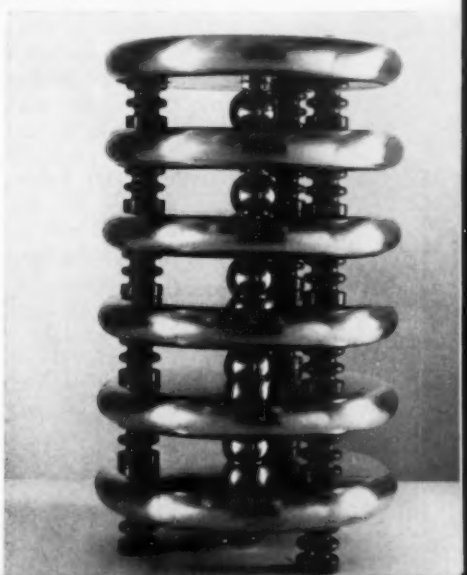


Mylar polyester containers *for liquid hydrogen. These containers are used as targets for accelerated beams of charged particles. They are made from two 10-mil thick layers of Mylar which are bonded together and to the metal bottom with an equal parts mixture of liquid epoxy and polyamide resins. The containers are protected from heat during operation by suspending them in a high vacuum vessel.*



Epoxy-glass vacuum tank sections. *This ring-shaped assembly is hollow and serves as a vacuum tank for the electron synchrotron. It was originally made of quartz but, because it was sometimes necessary to replace sections, designers had to find a material that cost less and could be fabricated easier. The best material proved to be an epoxy-glass cloth laminate filled with glass beads.*

Polyvinyl chloride insulators. *PVC is used for many high voltage parts that must be self-extinguishing. This six-deck, 500,000-v voltage-dividing resistor has three PVC insulators between each plate. These insulators proved quite useful as simple replacements for ceramic stand-off insulators.*



Based on a paper presented before the Society of Plastics Engineers Conference, Jan '60, Chicago.

Rare Earths:

Sixteen New Metals Are Ready to Use

New separation techniques have made them available in quantity. They may lead to a whole new range of structural, magnetic and nuclear alloys.

by B. Love and E. V. Kleber, *Research Chemicals Div., Nuclear Corp. of America*

■ Rare earths, which in fact are neither rare nor earthy, are the elements whose atomic numbers range from 57 to 71. These elements actually are half as abundant as carbon and chlorine, and even the scarcest are more abundant than cadmium, silver, bismuth, gold or platinum.

In order of increasing atomic number the rare earths are: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), and lutetium (Lu). Promethium, atomic number 61, does not occur naturally and will not be discussed in this article. Scandium (Sc) and yttrium (Y), atomic numbers 21 and 39, occur together with the rare earths in nature and are also Group III elements in the periodic table. They are usually included in the term "rare earths" and will be discussed here.

What made the rare earths rare?

The existence of the rare earth elements and their location in the periodic table have been known for many years. They are distinguished from other groups of elements in that they constitute an *inner* transition series, i.e., the electronic structure that distinguishes one element from the other is deeply buried. Since chemical properties are determined by the *outer* electronic structure, which is the same for all members of the rare earth group, chemical properties of these elements are very similar. Separating them from each other in any appreciable quantity, and with a high degree of purity, has consequently been very difficult and time-consuming in the past.

With the development of ion exchange and solvent extraction techniques, and the application of these processes to the separation of the rare earths, the tedious tasks of fractional crystallization and precipitation were eliminated. Availability of purified oxides in quantity rekindled interest in the metals. Research into methods of reduction, particularly at the Institute of Atomic Research, Iowa State College, led to methods for the preparation of massive metal, pure with respect to other rare earths and also with respect to most other elements. For example, the rare earth metals used to obtain data for this article had a maximum impurity content of 0.5%. Lutetium was the exception and contained 3% impurities.

Latest data on design properties

Use of rare earth metals for their intrinsic properties has been severely limited. Relative scarcity of the metals and misconceptions concerning mechanical properties and oxidation rates were the underlying factors. Observations made on impure misch metal (a rare earth alloy containing approx 50% Ce plus 50% La, Nd and similar elements) pointed to low strength and rapid oxidation. These conclusions were extended to cover all rare earth metals.

Mechanical properties and oxidation stability of the rare earths are not the same for all metals in the group. Tensile strength of pure yttrium and of the higher-atomic-number rare earths is significantly higher than that of misch metal. Actually, mechanical properties are of the same order of magnitude as in many unalloyed, more commonly used engineering materials such as titanium, copper, aluminum and magnesium. Similarly, atmospheric oxidation rates of yttrium and many of the higher-atomic-number rare earths are slower by several orders of magnitude than those of cerium or lanthanum.

Mechanical properties

Mechanical properties of pure rare earth metals in both the as-

TABLE 1—MECHANICAL PROPERTIES OF RARE EARTH METALS AS CAST

Metal	Room Temp					400 F			800 F		
	Ult Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Izod Impact, ft-lb	Vickers Hardness No.	Ult Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Ult Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
Yttrium	35.4	28.5	9	1.5	99	19.0	18.5	3	—	—	—
Lanthanum	18.2	17.2	8	4.5	51	15.3	12.4	9.4	6.7	3.75	21
Cerium	14.8	13.2	24	2.2	31	5.7	4.7	21.4	—	—	—
Praseodymium	14.5	14.3	10	4.8	45	20.1	14.7	15.8	6.7	5.8	30
Neodymium	23.9	22.9	11	8.3	83	—	—	—	6.0	5.7	13
Samarium	18.0	16.2	2.5	0.5	64	21.0	17.9	10.4	12.0	11.0	5.6
Gadolinium	26.4	25.1	8	1.3	66	18.0	15.6	6.8	14.1	13.0	11.3
Dysprosium	35.1	32.6	6	1.6	93	30.8	20.8	8.3	—	—	—
Holmium	37.5	32.1	5	7.1	90	30.8	24.6	6.0	—	—	—
Erbium	41.4	38.7	4	1.2	120	34.7	29.6	5.5	25.1	21.8	6.8
Ytterbium	10.4	9.5	6	5.3	—	10.2	7.8	10.8	—	—	—

TABLE 2—MECHANICAL PROPERTIES OF RARE EARTH METALS AFTER 50% COLD REDUCTION

Metal	Room Temp					400 F			800 F		
	Ult Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Vickers Hardness No.	Work-ability	Ult Ten Str, 1000 psi	Ult Str, 1000 psi	Elong, %	Ult Ten Str, 1000 psi	Ult Str, 1000 psi	Elong, %
Yttrium	65.5	53.0	3.4	140	Works well	57.9	27.7	4	32.1	23.9	4
Lanthanum	32.0	27.0	4.3	150	Fair	26.0	23.9	9	4.8	4.2	27
Cerium	21.9	16.5	16	48	Works well	13.7	11.3	9	5.1	2.0	8
Praseodymium	31.2	28.8	7.1	76	Poor; hot swaged	26.5	25.3	12	6.1	5.4	48
Neodymium	30.0	—	2.0	76	Works well	19.9	17.7	10	12.6	11.9	16
Samarium	—	—	—	—	—	24.8	19.2	14	14.5	13.0	12
Gadolinium	56.5	39.0	6.6	97	Easy just below red heat	41.8	30.0	4	19.2	14.2	19
Dysprosium	62.0	47.0	2.5	117	Fair	47.8	36.6	23	29.0	26.7	4
Erbium	50.8	41.0	11	161	Poor; hot worked	52.0	43.7	4	29.5	25.3	5

cast and 50% cold worked conditions are summarized in Tables 1 and 2. Yield and tensile strengths were determined at 77, 400 and 800 F. Values are relatively low for the lower-atomic-number elements and increase with increasing atomic number, with the exception of ytterbium. Yttrium values are comparable to those of the higher-atomic-number rare earths. The trend is similar at all testing temperatures for both cast and wrought metals.

Comparing the data in Tables 1 and 2 indicates that the as-cast materials are more ductile than the wrought. Cold working results in lower elongation while tensile and yield strengths increase. Note that the increase in tensile and yield strength is greater for the higher-atomic-number rare earth metals than for the lower-number metals.

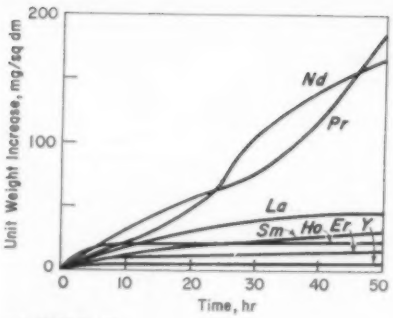
TABLE 3—OXIDATION RATES OF RARE EARTH METALS IN AIR
(Mg/Sq Dm/Day)

Temperature	95 F		205 F		390 F	750 F	1110 F
Relative Humidity	<1%	75%	<1%	75%			
Lanthanum	80	950	510	21,000	30	3,200	13,000
Cerium	—	—	—	—	—	200,000	—
Praseodymium	8	76	900	5,500	80	38,000	130,000
Neodymium	2	7	60	2,000	70	380	4,800
Samarium	0	0	0	100	15	17	35
Gadolinium	1	2	0	35	0	210	16,000
Terbium	0	0	0	—	0	1,600	40,000
Dysprosium	0	0	0	43	—	350	6,600
Holmium	1	1	1	—	11	110	5,400
Erbium	1	1	0	—	10	90	720
Ytterbium	—	—	—	—	—	170	—
Yttrium	1	1	2	9	4	40	1,900

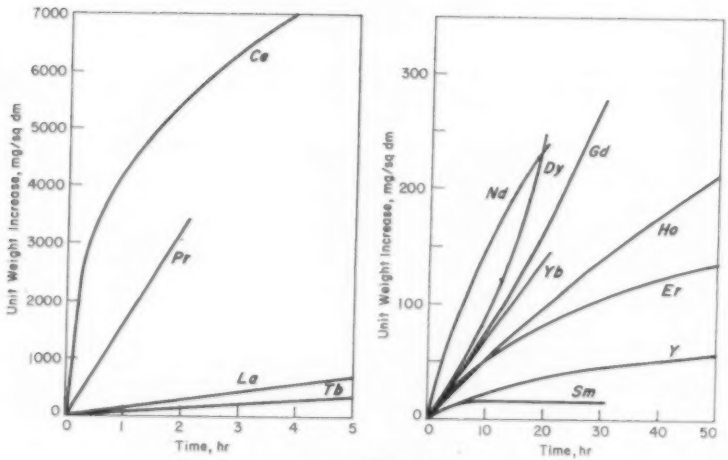
Ductility of many of the rare earths showed appreciable scatter during the testing program. No significant correlations of ductility with atomic number, strength or testing temperature can be made with the available data. Hardness also showed considerable variation and could not be correlated either with degree of cold work or strength.

All of the as-cast rare earth metals can be considered notch sensitive on the basis of impact

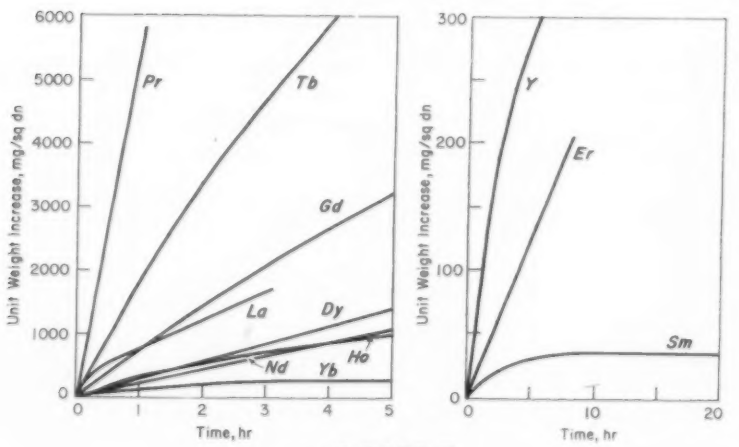
Oxidation Resistance of Rare Earth Metals . . .



. . . at 390 F



. . . at 750 F



. . . at 1100 F

data presented in Table 1.

Oxidation and corrosion resistance

Rare earth metals have a typical metallic appearance, generally similar to that of iron. Oxidation changes lanthanum, cerium and europium surfaces very rapidly. Neodymium and the other lower-atomic-number elements form a thin surface oxide film but remain fairly stable. Yttrium and the higher-atomic-number elements may maintain their luster for several months under ordinary atmospheric conditions.

Atmospheric oxidation data have been determined in detail for the individual rare earth metals. Oxidation rates are summarized in Table 3, and rates at 390, 750 and 1110 F are shown in the accompanying curves. Although there is a general trend toward greater stability with increasing atomic number, considerable individuality and some rather unexpected behavior occur.

Corrosion—Lanthanum, cerium, praseodymium and neodymium corrode rapidly. The effect of water vapor is apparent in Table 3: corrosion rate increases by approximately an order of magnitude at 75% RH compared to corrosion in dry air. This may help to explain differences in stability of these metals as reported from time to time by various laboratories throughout the world.

Oxidation—The curves show that most of the weight gain for the rare earths occurs in the first few hours of exposure, followed by essentially little or no weight increase over a longer period. Samarium exhibits the most startling behavior: even at 1110 F the oxidation rate is low, with the principal weight gain taking place during the first few hours.

Terbium shows a very rapid increase in oxidation rate at 750 and 1110 F, surpassing its neighbors on either side. Yttrium exhibits the lowest oxidation rate, except for samarium, at 750 F but the rate increases at 1110 F to exceed that of erbium.

Surfaces can be passivated—Cerium was the first rare earth element to be successfully passivated. After polishing for metallographic examination, the specimen was immersed in a 2 to 5% solution of nitric acid in ethyl alcohol. The dark colored corrosion film which started forming immediately after polishing changed to a yellow de-

posit. This deposit was removed by swabbing with alcohol and the process was repeated until the yellow deposit no longer formed. After the last rinse, a metallic luster appeared which was stable for several months.

Lanthanum, praseodymium and neodymium have also been passivated by the treatment. Although the results were not as striking, the surfaces were protected well enough so that metallographic examination could still be made after many hours.

Physical properties

Electrical—Electrical property data (Table 4) show that the rare earths are poor conductors of electricity, with specific resistances falling within the range 70 to 140×10^{-6} ohm-cm. Resistance anomalies occur at magnetic transformation temperatures. Most rare earths exhibit a normal decrease in resistivity as a function of pressure. Ytterbium, however, has been found to increase its resistivity by a factor of 12 when pressure is increased from atmospheric to 860,000 psi. Lanthanum is a superconductor at temperatures approaching absolute zero.

Magnetic—All of the rare earth metals are paramagnetic. Most are quite strongly so and are comparable to the transition elements chromium, manganese, iron and nickel. In addition, gadolinium, terbium, dysprosium, holmium and erbium are ferromagnetic at temperatures which range in decreasing order from 61 F for gadolinium to –423 F for erbium. Some magnetic properties of the rare earth metals are presented in Table 5.

TABLE 4—ELECTRICAL PROPERTIES OF RARE EARTH METALS

Metal ↓	Spec Res at 32 F and Atm. Pressure, 10^{-6} ohm-cm	Temp Coef of Res. (32 to 68 F), per °F
Scandium	6.1	0.00157
Yttrium	57	0.00151
Lanthanium	57	0.00121
Cerium	75	0.00048
Praseodymium	68	0.00095
Neodymium	64	0.00091
Samarium	88	0.00082
Europium	90	—
Gadolinium	140.5[a]	0.00098[a]
Terbium	—	—
Dysprosium	56	0.00066
Holmium	87	0.00095
Erbium	107	0.00111
Thulium	79	0.00108
Ytterbium	30	0.00072
Lutetium	79	0.00133

[a]Ferromagnetic.

TABLE 5—MAGNETIC PROPERTIES OF RARE EARTH METALS

Metal ↓	Room Temp Susceptibility, 10^{-6} emu	Magnetic Moment, Bohr magnetons	Ferromag Curie Temp θ_f, F
Sc	8.1	0	—
Y	191	0	—
La	101	0	—
Ce	2,310	2.5	—
Pr	5,320	3.6	—
Nd	5,370	3.6	—
Sm	1,260	1.5	—
Eu	40,600	3.5	—
Gd	Ferromag	7.95	61
Tb	191,000	9.7	–67
Dy	92,600	10.6	–306
Ho	70,200	10.6	–423
Er	49,200	9.6	–423
Tm	26,100	7.6	–420
Yb	70	4.5	—
Lu	18	0	—

Where can rare earths be applied?

Although it appears unlikely that any of the rare earth metals, individually, will become "common" structural metals in the sense that steel or aluminum are at present, their specialized properties and increased availability will lead to expanded applications.

Historically, the principal use of rare earth metals has been for the production of pyrophoric alloys: sparking flints for lighters are alloys of misch metal with iron. Misch metal is also used to provide rare earth additions in ferrous and nonferrous alloys. In the ferrous alloys, rare earths act as deoxidizers or scavengers; in aluminum and magnesium alloys they are added as specific alloying elements. For example, the elevated temperature properties of magnesium alloys are increased by rare earth additions.

Potential fields of application for the rare earth metals are obviously defined by their properties and the economics of their production and application compared to other metals. Although the properties of the pure metals are just being established, here are some potential fields of interest:

1. *As structural materials*—Specific gravity of scandium is only slightly higher than that of aluminum; that of yttrium is almost exactly the same as that of titanium. The other rare earth metals are about the equivalent of iron, nickel or cobalt in density. Melting points are in about the same range as those of the latter three elements. The potential of rare earth metals and alloys as structural materials, either as alloy base materials or alloy additions, should be investigated further. This is particularly true in the area of missiles and rockets where critical applications require only small quantities of specialized materials. Nonmilitary applications, particularly alloying additions to improve the properties or processing of more commonly used metals, also seems to hold promise.

2. *As magnetic materials*—The low temperature ferromagnetic properties of some of the rare earth metals open whole new fields of investigation for magnetic alloys. The electrical properties might lead to unusual modification of the properties of present alloys.

3. *As nuclear materials*—The wide range of thermal neutron cross sections of the rare earth metals have been known for many years. Present availability of the rare earths as metals should stimulate futher interest in their application.

How to Use Probability Paper to Solve Materials Problems

It can help you

1. *Set specification limits*
2. *Check material or process performance over a period of time*
3. *Check a supplier's claims*

by Donald Peckner, *Associate Editor, Materials in Design Engineering*

■ Application of statistical quality control principles is simplified when arithmetic probability paper is used. This type of paper has as its abscissa a probability scale, and as its ordinate a linear arithmetic scale on which the variable is plotted.

On a probability plot, a large amount of data, which may extend over a wide range, is condensed to only two numbers: the arithmetic mean $\overline{X}$, and the estimate of the standard deviation, s. For most engineering purposes, the arithmetic mean and the estimate of standard deviation, together, furnish the information necessary so that a material can be used.

Since 50% of the total number of observations will be above, and 50% below, the arithmetic mean, the intercept of the ordinate and the 50% abscissa can be read to obtain the mean directly.

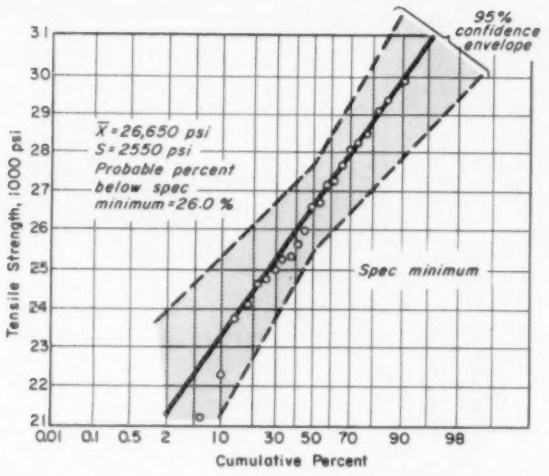
To obtain the value of s, another well-known property of the normal distribution is used. On probability paper the area under the curve between the 16% and 84% abscissas is equivalent to the value of $\overline{X} \pm s$. Therefore, determining the intercept of the curve with the 84% abscissa and subtracting $\overline{X}$ will give the value of s directly.

How to plot the data

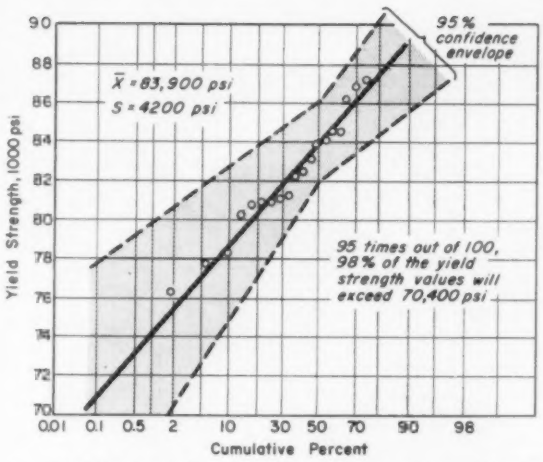
The next few paragraphs describe how to plot data on prob-

TABLE 1—CUMULATIVE PERCENTS CORRESPONDING TO VARIOUS SAMPLE SIZES

Observation Number	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	5	4.5	4.2	3.8	3.6	3.3	3.1	2.9	2.8	2.6	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.9	1.8	1.7	1.7
2	15	13.6	12.5	11.5	10.7	10.0	9.4	8.8	8.3	7.9	7.5	7.1	6.8	6.5	6.25	6.0	5.8	5.6	5.4	5.2	5.0
3	25	22.7	20.8	19.2	17.8	16.7	15.6	14.7	13.9	13.2	12.5	11.9	11.4	10.9	10.4	10.0	9.6	9.3	8.9	8.6	8.3
4	35	31.8	29.2	26.9	25.0	23.3	21.9	20.6	19.4	18.4	17.5	16.7	15.9	15.2	14.6	14.0	13.5	13.0	12.5	12.1	11.7
5	45	40.9	37.5	34.6	32.1	30.0	28.1	26.4	25.0	23.7	22.5	21.4	20.4	19.6	18.75	18.0	17.3	16.7	16.1	15.5	15.0
6	55	50.0	45.8	42.3	39.2	36.7	34.4	32.3	30.6	29.0	27.5	26.2	25.0	23.9	22.9	22.0	21.2	20.4	19.6	19.0	18.3
7	65	59.1	54.2	50.0	46.4	43.3	40.6	38.2	36.1	34.2	32.5	30.9	29.6	28.3	27.1	26.0	25.0	24.1	23.2	22.4	21.7
8	75	68.2	62.5	57.7	53.5	50.5	46.9	44.1	41.7	39.5	37.5	35.7	34.1	32.6	31.25	30.0	28.9	27.8	26.8	25.9	25.0
9	85	77.3	70.8	65.4	60.7	56.7	53.1	50.0	47.2	44.8	42.5	40.5	38.7	37.0	35.4	34.0	32.7	31.5	30.4	29.3	28.3
10	95	86.4	79.2	73.1	67.8	63.3	59.4	55.9	52.8	50.0	47.5	45.2	43.2	41.3	39.6	38.0	36.6	35.2	33.9	32.8	31.7
11		95.5	87.5	80.8	75.0	70.0	65.6	61.8	58.4	55.3	52.5	50.0	47.7	45.7	43.75	42.0	40.4	38.9	37.5	36.2	35.0
12			95.8	88.5	82.1	76.7	71.9	67.7	63.9	60.6	57.5	54.7	52.2	50.0	47.9	46.0	44.2	42.6	41.1	39.7	38.3
13				96.2	89.2	83.3	78.1	73.6	69.4	65.8	62.5	59.5	56.8	54.4	52.1	50.0	48.1	46.3	44.6	43.1	41.7
14					96.4	90.0	84.4	79.5	75.0	71.1	67.5	64.4	61.4	58.7	56.25	54.0	51.9	50.0	48.2	46.6	45.0
15						96.7	90.6	85.4	80.6	76.4	72.5	69.1	66.0	63.1	60.4	58.0	55.8	53.7	51.8	50.0	48.3
16							96.9	91.2	86.1	81.6	77.5	73.8	70.5	67.4	64.6	62.0	59.6	57.4	55.4	53.7	51.7
17								97.1	91.7	86.9	82.5	78.6	75.0	71.8	68.75	66.0	63.5	61.1	58.9	56.9	55 0
18									97.2	92.2	87.5	83.4	79.6	76.1	72.9	70.0	67.3	64.8	62.5	60.4	58.3
19										97.4	92.5	88.1	84.1	80.5	77.1	74.0	71.2	68.5	66.1	63.8	61.7
20											97.5	93.0	88.6	84.8	81.25	78.0	75.0	72.2	69.6	67.3	65.0
21												97.7	93.2	89.2	85.4	82.0	78.8	75.9	73.2	70.7	68.3
22													97.7	93.5	89.6	86.0	82.7	79.6	76.8	74.2	71.7
23														97.9	93.75	90.0	86.5	83.3	80.4	77.6	75.0
24															97.9	94.0	90.4	87.0	83.9	81.1	78.3
25																98.0	94.2	90.7	87.5	84.5	81.7
26																	98.1	94.4	91.1	88.0	85.0
27																		98.1	94.6	91.4	88.3
28																			98.2	94.9	91.7
29																				98.3	95.0
30																					98.3



1—*Distribution of tensile strength on arithmetic probability paper is accurate check on material performance.*



2—*Distribution of yield strength forecasts minimum expected values for use in setting specification limits.*

ability paper in two situations: 1) when the number of data is small, and 2) when the data are available in large quantities that cannot be conveniently handled without grouping.

After arranging the data so that cumulative percentages can be obtained and plotted, the next step is to determine the scatter of data that might be encountered. This can be done by making use of the confidence envelope which is described in detail in an accompanying box.

When the number of data is small (30 or less)—Arithmetic probability paper, in this case, is used as follows:

1. Arrange the data in order of increasing magnitude and assign each datum point a cumulative percentage value from Table 1.

2. Choose an appropriate scale on the abscissa and plot the data against the appropriate cumulative percentage value on the ordinate.

Table 2 is an example of random numbers rearranged and assigned a cumulative percentage from Table 1.

When the number of data is large—When more than 30 observations must be plotted, the method just described becomes both lengthy and tedious. The procedure is varied as follows:

1. Tabulate the number of observations that lie in equal-sized intervals. The interval should be at least 10 times the last significant figure to which the values are measured.

2. Calculate the percentage of observations in each interval and determine the cumulative percentage in and below the interval.

3. Plot the cumulative percent on the probability scale against the *top* of each interval on the abscissa.

A typical arrangement of data is shown in Table 3.

TABLE 2—ARRANGING DATA FOR USE WITH TABLE 1

Observation	Rearranged, Magnitude Increasing	Cumulative Percent[a]
477	370	4.2
370	440	12.5
491	453	20.8
463	471	29.2
440	477	37.5
495	478	45.8
506	486	54.2
509	491	62.5
471	493	70.8
486	495	79.2
478	506	87.5
493	509	95.8

[a]Taken from Table 1.

How probability paper can be used

To check material performance—Fig 1 demonstrates the use of arithmetic probability paper to check performance of a material. The data represent a permanent mold cast aluminum alloy with a specified minimum tensile strength of 25,000 psi. Data were obtained over a three month period. As seen in Fig 1:

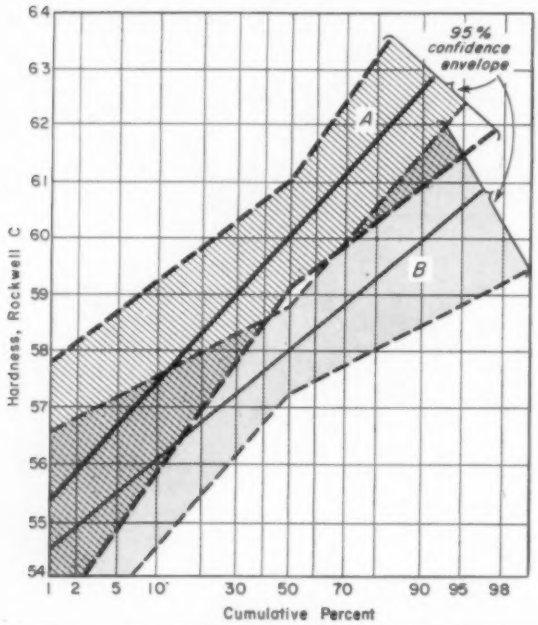
1. Average tensile strength to be expected is 26,650 psi.

2. By inspection, the intercept of the specification minimum and the curve indicates that 26% of

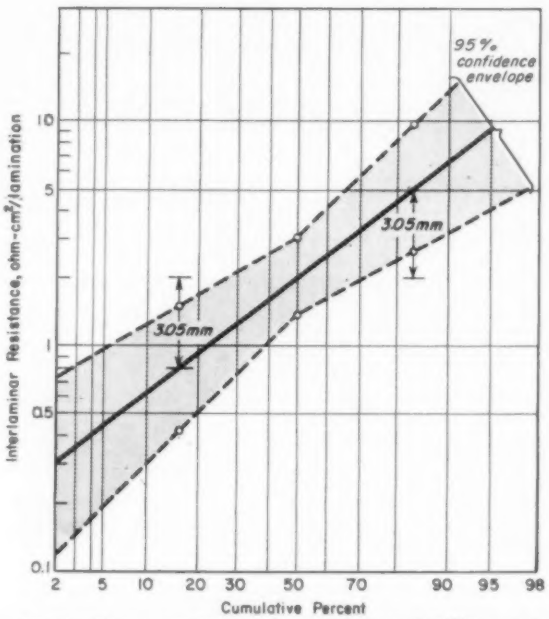
TABLE 3—ARRANGING LARGE NUMBERS OF OBSERVATIONS

Interval, arbitrary units	Number of Observations In Each Interval	Observations In Each Interval, %	Cumulative Percent
6.01-6.10	1	0.5	0.5
6.11-6.20	9	4.5	5.0
6.21-6.30	36	18.0	23.0
6.31-6.40	68	34.0	57.0
6.41-6.50	57	28.5	85.5
6.51-6.60	24	12.0	97.5
6.61-6.70	4	2.0	99.5
6.71-6.80	1	0.5	100.0[a]

[a]This number cannot be plotted since, theoretically, it is at infinity on this scale.



3—*Two groups of hardness data are compared. Since confidence envelopes do not overlap at the 50% ordinate, the groups are different and Process A will produce better results than Process B 95% of the time.*



4—*Confidence envelope for logarithmic probability paper. Estimate of standard deviation (s) is made equivalent to distance between 50% ordinate and either 16% or 84% ordinate.*

the material will probably be below the specification minimum.

3. The confidence envelope indicates that 95 times out of 100, as little as 7.5% and as much as 45% of the material can be expected to exhibit a tensile strength below the specification minimum.

Probability paper, then, shows the engineer how well a material is performing and suggests a course of action to follow. In this case, there are two possible courses: either revise the specification properties in accordance with the facts of actual performance, or choose a new alloy for the application.

To set up specification limits—Take a case where a literature survey turned up a promising casting alloy but, as usual, only average mechanical properties were quoted. Since an arithmetic average gives no indication of values at the extremes of a distribution, a more precise estimate of mechanical properties was needed for specification purposes.

By pouring tensile bars from several experimental heats, it is possible to forecast the minimum expected values of yield strength, tensile strength, elongation, etc., and incorporate them into a specification. In this use the probability plot in Fig 2 indicates that 95% of the time a specified yield strength of 70,000 psi will be obtained 98 times out of 100.

To compare sets of data—An additional useful application of arithmetic probability paper is the comparison of several sets of data to determine whether they were picked from the same or from different distributions. This is a general engineering problem since many situations occur where a design or process is changed and a decision must be made as to whether a real improvement has been obtained, i.e., an improvement that matches the economic factors involved.

Two heat treating methods gave the hardness results plotted in Fig 3. Although the variation in hardness produced by process A is no less than that produced by process B, a comparison of the arithmetic means ($\overline{X}$) shows that process A will consistently produce higher average hardness values. Since the confidence envelopes do not overlap at the 50% ordinate, it can be stated with 95% confidence that the two heat treating processes are significantly different.

When data are not normally distributed

One major shortcoming of probability paper should be noted here. If the data do not fall on an approximately straight line when plotted on arithmetic probability paper, this method of analysis cannot be used. Radical deviation from a straight line indicates a skewed distribution (some types of data, such as measurements of interlaminar resistance or stress rupture, seem to be inherently skewed), whereas the scale of the abscissa has been based on a normal distribution. The ease with which the arithmetic mean ($\overline{X}$) and the estimate of standard deviation (s) can be obtained sometimes leads to an artificial "fit" of a straight line to the data with the consequence that invalid data are obtained. If the data are skewed, then $\overline{X}$ and s must be calculated mathematically

or the distribution of logarithms of the observations must be considered.

If logarithms are used, two approaches are possible. In the first, the logarithms of the observations are plotted on arithmetic probability paper. This is often more convenient than using logarithmic probability paper because the scale of the abscissa can be chosen to fit each set of data, while the logarithmic probability paper has a fixed number of cycles. If logarithmic probability paper has a fixed number of standard deviation, s, is obtained by subtracting the log of the 50% value from the log of the value at 84% and expressing s as the difference in logs or in fractions of log cycles.

The confidence envelope—If the logarithms of a set of observations are plotted on arithmetic probability paper, the mechanics of determining the confidence envelope are the same as those noted in the box. If logarithmic probability paper is used, the method for calculating the limits of the confidence envelope is varied slightly. Rather than estimating s on the basis of log differences, measure the distance between the 50% ordinate and 16% or 84% ordinate as shown in Fig 4. This distance is representative of the value of s and may be substituted for s in the equation used to determine the limits of the confidence envelope (see box).

Consult a statistician in planning experiments

The graphical methods just described are excellent tools for evaluating properties of materials and processes after data have been obtained. If possible, the services of a statistician should be obtained *before* a program is run in order to obtain maximum benefits from a minimum of data.

The statistically designed experimental program, as opposed to the normal engineering "one at a time" approach, will vary several parameters at one time. A statistical design may evaluate the existence of interactions between several variables, usually one of the pitfalls of the "one at a

FACTOR k FOR MULTIPLYING THE ESTIMATED STANDARD DEVIATIONS OF $\overline{X}$ AND s TO OBTAIN CONFIDENCE ENVELOPES

Probability Level, %	Sample Size			
	10-15	16-20	21-30	Very Large
90	1.78	1.73	1.71	1.65
95	2.17	2.10	2.06	1.96
99	3.03	2.88	2.79	2.58

The Confidence Envelope

Its significance

In Fig 1-4 note that an "envelope" has been drawn around the curve representing test observations. The confidence level chosen and the confidence envelope associated with it are used to answer the question, "How reliable are the statements that have been made?"

Note also that two sets of similar observations on the same material, plotted on probability paper, will give rise to slightly different distributions. The use of a confidence envelope, which takes into account errors in the mean ($\overline{X}$) and estimate of the standard deviation (s), becomes a necessity if the interval within which a distribution lies is to be determined.

The "confidence level" desired must be determined. For most engineering purposes, the 95% confidence level is generally chosen. The degree of certainty associated with this confidence level will satisfy almost all engineering requirements.

One danger of using too high a confidence level (such as the 99% level) arises from the fact that in many engineering investigations a great many observations cannot be made. Fig 5 on the next page indicates that the degree of reliability increases with the number of observations. It also increases when the confidence level is decreased. In other words, as the width of the confidence envelope decreases, the amount of scatter to be expected in data also decreases. By sacrificing some degree of certainty it is possible to actually increase the practical utility of a statement of material properties.

How to construct it

Drawing the confidence envelope is done on the basis of the following facts:

1. The true arithmetic mean lies within the interval
$$\overline{X} \pm ks/\sqrt{n}$$
2. The true standard deviation lies within the interval
$$s \pm ks/\sqrt{2n}$$

The constant, k, depends on the number of observations and desired confidence level, while n represents the number of observations. The accompanying table lists approximate values of k for different confidence levels and sample sizes.

Using the values of $\overline{X}$ and s derived from Fig 1, the confidence envelope for these observations was derived as follows:

The arithmetic mean lies within the range $\pm ks/\sqrt{n}$. From Fig 1, we note that $\overline{X} =$ 2550 psi. From the accompanying table, on the basis of a 95% confidence level and 22 observations, $k = 2.06$. Therefore, $ks/\sqrt{r} = \pm (2.06)(2550)/\sqrt{22} = \pm 1120$ psi.

The range of the estimate of the standard deviation is $\pm ks/\sqrt{2n}$. Since k and s remain the same, the interval is $\pm (2.06)(2550)/\sqrt{44} = \pm 790$ psi.

To construct the confidence envelope, at 50 cumulative percent plot two points: one 1120 psi above and one 1120 psi below the curve. At 16 and 84 cumulative percent, plot points 1910 psi (1120 psi + 790 psi) above and below the curve. Connecting the points produces the confidence envelope.

time" approach.

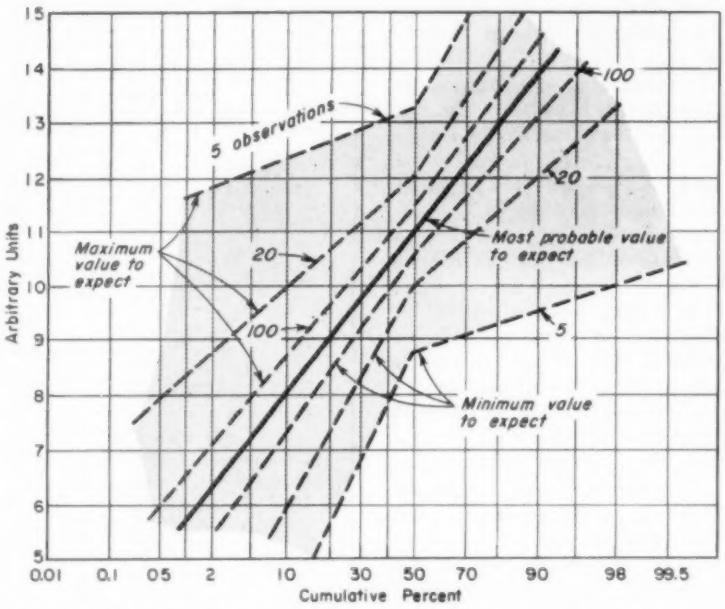
Statistical techniques permit the engineer to decide the minimum number of observations necessary to make a reliable decision. Since the cost of making each observation is usually fixed, such knowledge can save the engineer both time and money.

The importance of statistics as a tool for all engineers cannot be overemphasized. It is a particularly valuable tool for those who are required to predict results or formulate additional, and possibly expensive, programs on the basis of a few test results. Large evaluation errors may be made when only a few samples can be taken. Consider, for example, these two diametrically opposed extremes of evaluation errors:

1. A positive result is obtained on the first trial when the probability of obtaining such a result is relatively low. This is an unfortunate situation since a large effort may be expended in an attempt to obtain the original result.

2. The reverse may occur and a negative result is obtained when the probability of obtaining a positive result is relatively high. This places the predictor in the position of, perhaps, discontinuing a potentially successful project. The unfortunate corrollary is that a large and wasteful effort may be made to develop another method when the first would have been the most satisfactory one.

(more E&D on p 171)



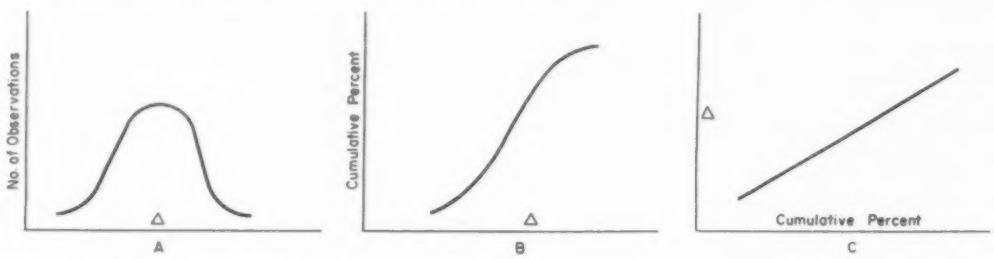
5—*Reliability increases as the number of observations increase. A similar effect results when the confidence level is decreased.*

What Is Probability Paper?

The development of arithmetic probability paper can be visualized as follows: Assume that *A* represents the standard normal distribution curve of a set of data, the familiar "bell-shaped" curve defined by $\phi(t) = (1/\sqrt{2\pi})e^{-t^2/2}$. Integrating $\phi(t)$ results in a curve similar to *B* on which is plotted the cumulative percent of observations at or below a given value, against that value. If the abscissa of *B* is now stretched symmetrically, but nonlinearly, about the 50% value, the curve becomes a straight line (C) and the scale of the abscissa becomes a probability scale. Cumulative percent is plotted on the probability scale since the probability curve represents the integral of the area under the normal probability curve. Cumulative percentages for varying numbers of observations are given in Table 1.

Getting the paper

Two sources for probability paper are: Codex Book Co., Norwood, Mass. (arithmetic—No. 3127, logarithmic—No. 3128), and Keuffel & Esser Co., New York City (arithmetic—No. 359-23, logarithmic—No. 359-22G).



A Special 4-Part Report on

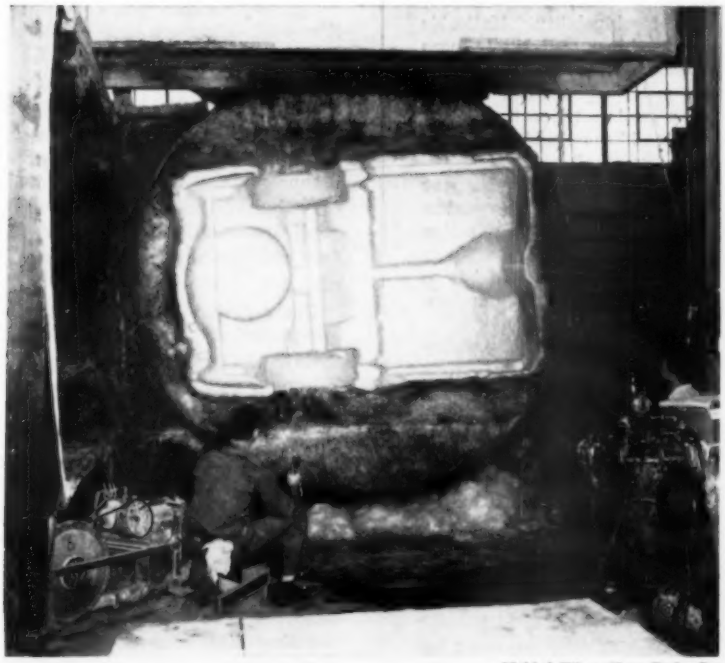
automobiles / *what materials are next?*

Smaller, lighter cars . . . new engine concepts . . . greater emphasis on safety . . . more corrosive atmospheres . . . and, above all, mounting costs . . . these trends are forcing automotive engineers to make some radical changes in the materials used for car and truck engines, bodies, trim and interiors. Here are the results of a recent field survey.

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

1 The Cost Battle: Metals vs Plastics

Plastics continue to replace metals for many functional and decorative parts. An all-synthetic interior may not be far off.



Molded Fiber Glass Body Co.

Corvette underbody *preform in early stage of manufacture.*

■ Aside from safety, cost is probably the most important single criterion used by automotive engineers in selecting a material. For every one of the thousands of parts in a car there are literally dozens of materials that will do the job. Engineers are constantly searching for the cheapest material that will perform a given function safely and efficiently.

At present, plastics account for less than 1% by weight (30-35 lb) of the materials used in a car. Yet they are being used in very significant applications and their use is growing rapidly. One manufacturer predicts that an average of 60 lb per car will be used by the end of the 1960's. Growth will be even more rapid if new resins are developed and if the cost of present materials continues to go down as the cost of metals continues to go up.

Let's take a look at important trends now taking place.

Acetal moldings are replacing metal stampings, die castings

Acetal (Delrin) is probably the most talked about group of plastics in the automotive industry today. Engineers are particularly enthusiastic about the material's combination of low cost and high strength and rigidity.

Acetal plastic is now being used in the Corvair as an improved (and lower cost) replacement for metal in the parking brake pulley and the segment pulley for the transmission control cable. Chrysler is taking a significant step next year by using an acetal resin molding for the Valiant dashboard instrument housing. This is one of the largest molded plastics parts ever used in a U.S. make and is important in that it was selected over a zinc die casting.

As of this writing zinc costs 3.87¢ per cu in. (16.25¢ per lb) vs 4.11¢ per cu in. (80¢ per lb) for acetal plastic. Despite acetal's slightly higher cost and the fact that zinc die castings could be turned out quicker, acetal moldings won out because they require less finishing. Acetal's advantage will become even greater if there is a further change in price. The cost of the two materials (on a volume basis) would become equivalent if zinc rose to 17.3¢ per lb and acetal stayed as is, or if acetal dropped to 75¢ per lb and zinc stayed the same. Most prices quoted in this article are as of October.

Another important reason why acetal was selected for the instrument cluster is its good load-carrying ability at high temperatures. It is not generally known but temperature is an important specification for car interiors. Dashboard temperatures as high as 250 F have been recorded in cars sitting in the sun with the windows closed. Also, interior temperatures can go over 200 F during repainting operations. Thus, organic materials have to be selected with great care.

Other applications in which acetal can be used are: windshield washer pumps, steering column housings, kingpin bushings and air hose brake connectors for trucks, blower wheels, carburetor and fuel pump housings, and many others. Since the material can be colored it can also be used for door and window crank handles. One make will probably use colored acetal door handles in 1961.

Reinforced plastics cut cost of short production items

There has been much talk in recent years about using reinforced plastics as a replacement for sheet metal in regular passenger cars. However, designers point out that a whole new concept in body design will be needed before reinforced plastics become widely accepted for large production runs. Both design concepts and production equipment are geared for sheet metal—a material whose low cost, strength and ease of fabrication are not to be denied.

Before reinforced plastics gain a strong foothold new fabrication methods will have to be developed. Hand layup is out of the question because of its slowness and poor reproducibility. And matched metal dies are still not fast enough for million-a-year production runs.

Designers also stress that to get sufficient strength in reinforced plastics you have to go to thicker sections—at increased cost. Stronger materials will have to be developed; possibly a combination of plastics with metals will do the trick.

Thus, for the immediate future it appears that reinforced plastics will be best suited for short production runs where they can eliminate the cost of expensive metal forming dies, such as in the current Corvette body and the cab for the White truck.

Automakers Also Seek Cheaper Metals

Automotive engineers are always looking for metals that provide good performance without presenting any excessive cost, processing or production problems. Right now there is considerable interest in high strength steels containing a minimum of costly alloying elements.

For example, car and truck engineers are finding that a properly processed carbon steel such as AISI 1012 M can replace alloy steel for universal joint bearing extrusions. This alloy was especially developed for cold forming and because of its good extrusion properties and lower cost is now being used for several applications.

The trend toward cold forming of steering gear components makes it mandatory that steels have a good surface finish. Surface defects show up badly during cold forming. Consequently manufacturers are putting lots of pressure on the mills to supply steel with a better surface finish.

With the trend to automatic machining designers have had to use a lot of leaded and sulfurized steels. These materials cost more. Also, designers are finding that greater control of materials such as gray iron is needed at the foundry to promote machinability. Malleable iron machines well but is more expensive than gray iron. As one metallurgist says, "If we had a good cast iron that would machine like malleable, then we'd be in business."

Another trend in steering gear design is to use medium carbon alloy steels that can be induction hardened. In some cases these materials have been found to be an excellent substitute for carburizing grades.

Aluminum is also gaining ground for steering gear components. A new use for this material is the steering gear housing (permanent mold casting) for the Corvair. Some other small aluminum die castings are also used in the steering gear assembly. The biggest problems right now are porosity and non-uniform machinability. Designers feel that the material's cost will have to be lowered and machinability improved before they undertake new uses.

Truck cab *for White Motor Co. is one-piece reinforced plastic molding. Tooling cost was only $39,000. If made as an assembly of steel parts, tooling cost would have been about $240,000.* (Molded Fiber Glass Body Co.)

According to Robert S. Morrison, president of Molded Fiber Glass Body Co., "The production quantity at which fiberglass-reinforced plastics affords a cost advantage over a steel car body has gone up from a 15,000 unit level in 1954 to a 25,000 to 30,000 unit level today. But today, top U.S. automakers are reported to be thinking in terms of 'segmented markets' with a greater variety of specialized vehicles. Besides the economy of producing the bodies of such smaller volume models in fiberglass, the material's lower tooling costs permit more frequent changes in design."

Aside from production economies, the reinforced plastics body for the Corvette offers advantages of light weight and easy repair. Many have speculated that designers would turn to a metal body if production rose; however, this appears unlikely due to the good acceptance of reinforced plastics.

The quest for higher payloads was an important reason why White designers selected reinforced plastics over metal for their truck cab. The density of glass-reinforced polyester is about 1.5 as compared to 7.8 for carbon steel and 2.7 for aluminum. Reinforced plastics, of course, require greater thickness than metal but total weight still works out to be less. Also, although labor and material costs are high with reinforced plastics, comparatively little tooling is required. Since the cab is molded instead of stamped, designers are free to use intricate shapes without fear of tearing or objectionable springback. The nonrusting properties of the material and its favorable thermal characteristics in both summer and winter also ruled in its favor.

It is interesting to note that glass-reinforced polyester bodies are widely used in England for special purpose, low production cars, trucks and buses. Typical of the cars now using such bodies are the Daimler, Berkeley, Elva, Fairthorpe, Jensen, Lotus, Nobel, Peerless, Reliant and Turner.

Polypropylene has a good future

All of the major auto companies have thoroughly evaluated polypropylene and it is only a question of time before it comes into its own for automotive use. The material offers low cost, toughness and scratch resistance. It has better scratch resistance than linear polyethylene and thus may hold the edge in future parts for car interiors. At 1.36¢ per cu in. the material is cheaper than all other plastics except polyethylene at 0.91-1.31¢ per cu in. and poly-

styrene at 0.82¢ per cu in. (general purpose) and 1.08¢ per cu in. (high impact).

Two of the most significant applications for the material to date have been radio grilles and the tops for linear polyethylene windshield washer reservoirs. Polypropylene is being investigated for center door post covers, garnish molding, kick panels and accelerator pedals. The latter use is particularly interesting in that it puts to use the material's excellent hinge properties (see "The Polypropylene Hinge: Long Life at Low Cost," M/DE, Oct '60, p 117) and colorability.

Polyethylene is attractive because of low cost

Polyethylene scored a major breakthrough in the 1960 Fords for seat side shields. This is one of the biggest plastics parts used in a car to date and success of the material will point the way toward future applications, notably kick shields forward of the door in the 1961 Ford.

The side seat molding is interesting in that because of cost and production uncertainties the shields were carried as dual programs in linear polyethylene and steel for several months. This offered an excellent comparison and polyethylene won out because it: 1) costs one-third less than painted stamped steel, 2) can be tooled at a cost one-third less than steel, 3) provides better appearance—part of it is grained and part is smooth, 4) lowers car weight by 2.8 lb, and 5) provides better scuff resistance.

Over 50 nylon parts used in some cars

Nylon has long been a popular material for cars, particularly because of its self-lubricating properties, quiet operation and comparatively low cost (Du Pont's prices range from *4.04 to 4.95¢* per cu in., depending on grade). The material is extremely popular for gears, bushings and bearings, and five 1960 models contain an average of 50 nylon parts (about 5 lb) per car.

Future applications for the material will center in two principal areas: cooling systems and tubing. The development of hydrolysis-resistant grades is expected to open up many new cooling system uses such as valve components, thermostat housings and radiator reserve tanks.

Hydraulic and fuel lines also offer good potential for nylon if economic problems can be worked out. In sizes up to ¼ in. nylon tubing is cheaper than metal; above ¼ in. metal tubing is cheaper. However, its latest cost drop is expected to make nylon competitive for larger tube sizes, such as those used for fuel lines. It has been tried and proven for this application and although nothing definite has been set for '61 models it may go in as a running change.

Also worth noting is that glass-filled nylon (as well as acetal and polystyrene) is getting lots of attention. Filled nylon looks good for many applications, but there are difficulties in obtaining a smooth finish for decorative parts

Outlook for polycarbonate depends on price

Like any new plastic, polycarbonate is undergoing thorough investigation by automotive designers. They feel that the material could be used in many applications where present plastics fall down because of low heat resistance. However, a big stumbling block for the material is its cost —6.5¢ per cu in. Other drawbacks, according to designers: shrinkage; adverse aging characteristics at low temperatures; and uncertain surface finish, which makes it necessary to select finishes with care.

Urethane foams taking over in upholstery

There was a time when the selection of upholstery materials was a straightforward problem. In the good old days designers had their choice of a broadcloth, leather and cotton. However, the choice has not been easy ever since the introduction of foam base materials and synthetic covering materials.

Foams are here to stay and it appears that the once widely used latex foams are giving way to urethanes having higher quality, strength and tear resistance. Although urethane foams cost more than latex foams on a per pound basis, the end cost of urethanes is lower because they can be used at lower density. Thus, if latex is going to compete it needs greater load-carrying capacity at low density.

Latex foams have always been noted for their excellent load-deflection characteristics and designers are finding it hard to get the urethanes to perform equally as well. Urethanes have a tendency to feel firm and they bottom more quickly than latex foams. But designers feel that this problem is slowly but surely being licked. High promise is held right now for the polyether-type urethanes (see "How Polyether Foams Compare," M/DE, Mar '58, p 101) whose load-deflection curves more closely match those of latex. Another important trend is the use of foamed-to-shape systems instead of slab-type foams which have to be cut to shape and thus promote waste.

In reflection of consumer tastes, the past few years have seen a great many changes in upholstery materials. Two separate developments saw wools replaced by nylon and leather replaced by vinyl. Then, because of its lower cost and cleanability, vinyl replaced nylon. Right now there is a desire for vinyls with high metallic content. However, as their cost goes down, we can expect to see increased use of noncoated nylon and polyester fabrics. Also, wherever possible, low cost moldings will be used to replace parts requiring sewing and stitching.

What Readers Think of Plastics in Cars

A special M/DE survey of almost 100 readers shows that most—but not all—would like more plastics in cars. The common refrain: "Plastics are good if properly engineered, designed and applied." For more details on the reader survey, see p 149.

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2 Piston Engine Materials: The Trend Is to Aluminum

At least four American cars will have lightweight aluminum engines in 1961—and there are more to come.

■ The cost of aluminum is no longer the drawback that it once was. Significant breakthroughs in two areas have reduced the cost of aluminum engine components to the point where they are directly competitive with cast iron. Of great significance is that molten aluminum can now be taken directly from reduction cells and transported in insulated containers directly to the foundry. Thus, remelting is eliminated and costs are cut. Concurrent with this development, improvements in permanent mold casting have resulted in better and lower cost parts, and it now appears that die casting will be suitable for quantity production of engine blocks.

Big breakthrough in 1961

As of this writing it is definite that at least five major U.S. cars will be using aluminum engines in 1961: Corvair, Rambler, and the new Oldsmobile, Pontiac (optional) and Buick compacts. Also, there is a good chance that three other makes will switch to aluminum in the course of the 1961 product run.

The use of aluminum in the rear-engined Corvair is well-known. Aluminum had to be used in this car to reduce weight on the rear wheels. Both die and permanent mold castings are used and, although engine cost has not been disclosed, the fact that GM's Corvair is priced competitively with Ford's Falcon which uses a cast iron engine indicates that GM is not paying a premium price for its all-aluminum engine.

The cylinder block of the new Rambler six-cylinder engine is being die cast. This is a first: large die cast blocks have never before been made on a production basis. Many experimental blocks have been made, and engineers owe a debt to Doehler-Jarvis and Kaiser Aluminum for their advance work. The aluminum blocks for the Oldsmobile and Buick compacts will be gravity-fed permanent mold castings.

Some problems unsolved

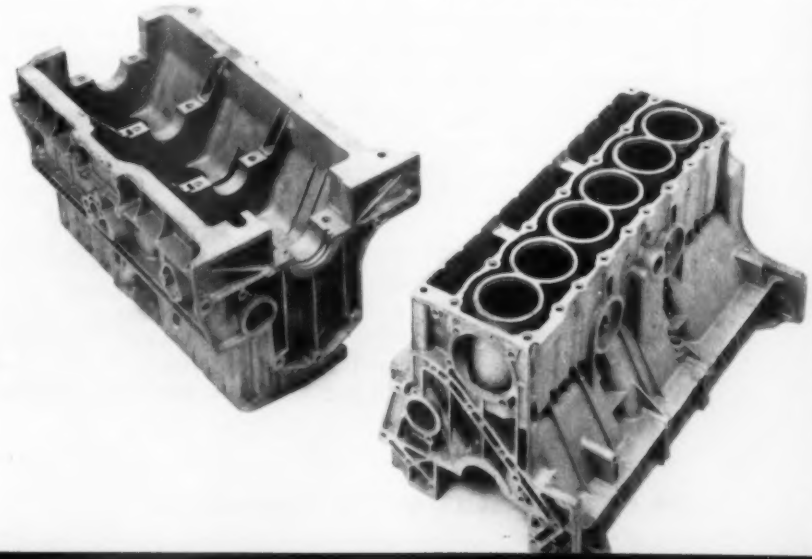
Despite the current accent on aluminum it is still problematical if aluminum will ever completely replace cast iron for engines. Because of its low cost and high strength, cast iron may continue to be the dominant engine material. Two current engine designs —the Ford Falcon and Renault Dauphine—are excellent examples of what can be done with the material. Aluminum is still experiencing growing pains and important problems remain to be solved.

Previous cost surveys have shown that the *materials* cost of a cast iron and a die cast aluminum block are about the same. However, production costs of the two blocks differ and it is the degree of difference that is causing some big headaches today.

Die cast aluminum has an advantage in that bolt holes need only be tapped, whereas holes in cast iron have to be drilled before tapping. This advantage is admittedly a small one and is offset by the fact that cast iron liners have to be used in die cast aluminum blocks to provide wear resistance. This raises costs considerably. If suitable wear resistant (and machinable) aluminum alloys or cheap and durable coat-

First die cast aluminum block *produced in this country is in the 1961 Rambler. A special aluminum-silicon alloy provides hardness and controlled temperature expansions. Gray iron cylinder liners are cast in place.*

Doehler-Jarvis Div., National Lead Co.



ings can be developed the metal's future will be greatly enhanced.

Thus, aluminum is both easier and harder to work with than cast iron. It is potentially useful and lends itself to die casting but, in the words of another metallurgist, "It is not really attractive unless you can die cast whole assemblies and eliminate a lot of machining. Aluminum is easier on tools but is not as reliable to machine, as it can be scored, torn and easily damaged. Also, it is not as reliable as cast iron because die casting can produce blow holes and porosity."

Aluminum's Bright Future

Latest estimates by Aluminum Co. of America show that America's automotive industry will consume nearly a billion pounds of aluminum a year by 1965, and that by 1975 every car may use 500 lb and possibly 1000 lb of the light metal. Current usage is running at about a million pounds a day or an average of 56 lb per car—up 11% over last year.

The five 1960 compacts alone used almost 90 million lb of aluminum at an average of 58 lb per car. Of these five the leading user of aluminum is the rear-engined Corvair with 103 lb per car. Valiant is next with 80 lb. On an industry-wide basis, Chrysler leads with 84 lb per car; the Imperial alone uses 115 lb.

Here is a breakdown of the average 1960 car (all makes) showing where aluminum is used:

Part	Lb per Car	% Total
Engine	20.60	36.7
Transmission	18.41	32.8
Hardware & Trim	8.42	15.0
Body	1.80	3.2
Electrical	2.47	4.4
Brakes	2.02	3.6
Steering	0.78	1.4
Air Cond & Heating	1.23	2.2
Air Suspension	0.17	0.3
Instruments	0.06	0.1
Miscellaneous	0.17	0.3
Total	56.13	100.0

No one has yet had any experience in die casting large parts such as engine blocks in great quantities. The dies will be expensive and it is hard to predict how long they will last. Also, the equipment required is very costly and no one can say if they will be used enough hours in the day to justify their high cost. Thus, even though die cast blocks can be made engineers are not yet sure if their cost will be within reason.

Future uncertain for cast iron

One important side effect of the increased use of aluminum is that it has created an increased awareness of how cast iron can be used more efficiently and to its full potential. There is little if any excess material in today's designs. And, in the words of one engineer, "Cast iron is still a hell of a good material to make an engine out of."

Nevertheless, cast iron producers and users will have to be on their toes to meet the challenge of aluminum. This will not be easy and members of the Gray Iron Founders' Society are deeply concerned with this problem. At a meeting of the Society in 1958, Dr. Robert Thomson of GM's research staff posed the following questions which may well determine gray iron's future:

1. Can you take hot metal directly from the blast furnace and avoid the remelting cupola operation?

2. Can you pour metal from an electric furnace into molds without entrapping slag as is usually done in a lip pouring ladle?

3. With research in new high temperature materials can you increase the scope of permanent molding?

4. What innovations can be introduced to produce thinner walled castings?

5. What can be done to improve special properties of cast iron such as wear resistance, damping capacity or modulus of elasticity?

6. Are you sure you cannot successfully die-cast cast irons?

Although some of these suggestions have previously been found impossible, they must be continuously examined in the light of changing economical and technological conditions.

Other important changes

In light of the publicity on aluminum engine blocks it is easy to overlook other significant materials changes now under evaluation. Here is a rundown of important changes to watch for:

Aluminum cylinder heads will become more commonplace (they are already popular in Europe) as a replacement for cast iron heads. Despite high cost they reduce weight and help dissipate heat.

Aluminum intake manifolds will be used more, especially where the manifold is water heated to promote vaporization. Exhaust manifolds will continue to be made of cast iron because aluminum tends to melt at the high temperatures encountered.

Aluminum and magnesium crankcases may be used for weight reduction in designs where the crankcase is divorced from the cylinder block. Such castings will be simple and can be constructed so that they are not excessively loaded.

Malleable iron connecting rods may substitute for forged rods.

Aluminum radiators may be used if copper costs get too high.

Ceramic coated mufflers will be used on 1961 American Motors line. However, aluminized steel will probably continue to be used on other lines for some time. Stainless steel mufflers look doubtful because of cost. Designers point out that large numbers of car owners do not have muffler failures (failure largely depends on type of driving) and question whether they should be penalized with high cost mufflers made of premium materials.

Magnesium may substitute for aluminum in nondecorative, structural applications. One manufacturer has specified either aluminum or magnesium for some die castings. However, aluminum has usually won out because of lower cost. Nevertheless, we may see more use of magnesium (as in Volkswagen) because of its light weight.

Results of a mail survey of M/DE readers

What Materials Engineers Say About the Materials Used In Today's Cars

Car failures are a big conversational topic among men. Men who drive well and provide proper maintenance—and still have trouble—certainly have a right to complain. But many men without a technical background are inclined to go off the track when it comes to pinning down the reasons for a difficulty and its possible remedies.

In the course of planning this special report on the materials used in today's cars, the editors decided to find out what a rather special group of men—M/DE's materials-oriented readers—had to say about the materials used in their own cars. To do so, we sent an eight-point questionnaire to 500 readers selected from our subscription list by random sampling. Just about 100 readers, or 20%, responded.

One thing was immediately obvious from the replies: M/DE readers are not much different from other men when it comes to expressing their irritation with car failures. But their replies show a greater awareness of the nature of the materials used, and of the materials problems encountered by automotive engineers, than is true in most conversations about cars—even among most engineers.

Here is a summary of what they say:

Electroplates draw most criticism

Roughly two-thirds of the M/DE readers replying to the questionnaire were dissatisfied with the durability of electroplates on today's cars. This is a critical problem; judging from the complaints of rusting through and chipping it is obvious that considerable improvement will have to be made. Although plating specialists are conscious of these deficiencies and hard at work to eliminate them, it will not be an easy job. Through no fault of their own, automakers are having to cope with worsening industrial environments and greater use of damaging rock salt. Nevertheless, even where these factors are not present it seems that electroplates are not performing properly.

Large majority prefer less brightwork

It is significant that over 70% of M/DE readers say that they want less brightwork on car exteriors. This reaction is not peculiar to our readers and Detroit is quite conscious of the general preference for less "chrome." As the new models already indicate, we can expect to see less brightwork in the future and greater use of body sculpturing to obtain decorative effects.

What about the trend away from troublesome chromium plating toward stainless and aluminum trim? A clear majority — 63% of those surveyed — prefer stainless to aluminum for exterior trim. About 7% prefer aluminum and another 21% say it does not make any difference. From users' comments it appears that before aluminum can gain a strong foothold for trim it will have to be made harder, used in thicker sections, and provided with a longer lasting protective coating.

Paints have improved

Although many readers complain that the paint on their cars has lost its appearance and durability, most readers appear to be satisfied. Many car owners believe today's paints are better than ever and commented that the new paints are holding up quite well. This opinion is reinforced by the paint suppliers and automakers who contend that the new paints will last the life of the car if properly cared for. It now appears that paint quality and durability cannot be improved much further unless users are willing to pay a higher price for extra coats and premium resins.

Muffler and exhaust systems draw lots of complaints

As expected, a large number of readers—at least 20%—complain that either their muffler or their tail pipe has failed, sometimes in less than a year. The problem is well known. One reader says: "It is ridiculous that a $3,500 automobile is delivered with a part which operates in a highly corrosive environment and is made from materials having absolutely no corrosion resistance."

Recently, automotive engineers have taken measures to reduce such failures. Most cars being made today are provided with aluminized

mufflers, and one 1961 line will even have a ceramic coated muffler (*Road & Track* magazine estimates that the additional cost of this muffler will be $1.50). Thus, as more cars on the road have aluminized and ceramic coated mufflers, we should expect to see a big reduction in failures.

Few complaints about body corrosion

Not too many complaints were made about body corrosion, but the problem is severe enough to warrant attention. Some readers point out that they have had bad rusting at points where paint was damaged, underneath fenders, and at the lower door sills. A casual look at the cars in any factory parking lot will quickly show that the problem is a long way from being licked. But with the increased use of protective coatings on car underbodies and in hidden areas we can expect to see less rusting in the future.

Engine materials are more reliable today

To anyone who has been driving for more than 20 years, it should be obvious that engine breakdowns because of materials failure are less common today than they used to be. Most failures today can be traced to overly complex design rather than materials. Years ago, carbon, valve and ring repairs were frequently needed, and such materials failures as blown head gaskets and worn crankshaft bearings were common.

Nevertheless, engine materials failures are still occurring frequently enough to be of some concern, and about one out of ten M/DE readers complains of poor materials. Such failures are costly, they are a nuisance, and, more than any other failure, they can give a bad name to a car.

Although it may not be statistically significant, it is interesting that two respondents have had engine block failures traceable to casting faults; one failure occurred after 27,000 mi and cost $235 to repair.

This was the only case where two readers reported the same type of engine failure. Other failures covered a wide range of components, including: flywheel (large segment severed after 15,000 mi), piston ring, valve stem, clutch and transmission, fuel pump diaphragm, piston rod, and connecting rod (after 100 mi in a 1960 car).

Owners say sheet metal is too thin

Over 10% of M/DE readers feel that body sheet metal is too thin. Although this is a common complaint, it is doubtful whether much can be done about it. Selection of optimum thickness is a compromise. Any addition in metal thickness to provide greater strength and corrosion resistance is accompanied by an increase in cost and a reduction in performance due to added weight. Car designers, at least, feel that they have reached the optimum metal thickness.

Most readers favor more plastics

Since many M/DE readers are successfully using plastics in their own products it is not surprising that they think that plastics have a bright future in cars as well. However, no doubt in reflection of their own experience, they point out that plastics will have to be carefully designed in order to make full use of their potential. Automakers seem to share their caution; plastics parts for cars are evaluated pretty thoroughly before adoption.

Despite these efforts quite a few readers are not satisfied with the use of plastics. Some believe that they do not belong in a high priced product. And others believe that they are being misapplied. Owners in the last group state that plastics are often not strong enough, that they tend to age and crack, and that they need to have greater resistance to temperature and ultraviolet light because of the increased glass area in cars.

Seal and molding materials could be better

Over 10% of M/DE readers complain about leakage problems. It is hard to tell whether failures are caused more by deteriorating materials or by poor design. Some elastomers in use still tend to crack and distort with age. If this aging were taken into account through more careful design (heavier sections, baffles, back-up seals, etc.) there is no question that leakage problems could be lessened.

Upholstery materials do not last long enough

This is a common complaint of M/DE readers. Considering the treatment upholstery receives, perhaps it is surprising that it lasts as long as it does. Yet some readers say that their upholstery has failed in a very short period—a seemingly inexcusable defect in view of the fabrics available today. When it comes to upholstery, however, are we willing to pay for materials that will last for years of constant use? Leather, for example, is one of the most durable upholstery materials known but its cost (about $200 extra in some European cars) is beyond the reach of most car owners.

3 The Body: A Quest for Quality

The trend to unit construction and the greater use of anti-iceing chemicals have posed new corrosion problems for automotive engineers. But finishes seem to get better all the time.

■ Corrosion has and always will be one of the biggest bugaboos of automotive engineers and designers. Thin metal sections are particularly susceptible to attack, and in recent years corrosion problems have been intensified by greater use of anti-icing chemicals and by the trend to unit construction bodies. Unlike separate chassis-body constructions, unit construction bodies contain many hidden areas and enclosed sections which tend to trap moisture and chemicals and promote corrosion. This is a very serious problem and has received much attention in recent years, particularly from American Motors, a long-time user of unit construction bodies, and by Chrysler, which has recently started to use the construction.

The battle against corrosion

American Motors believes that adequate corrosion protection can be obtained by coating all steel body surfaces, particularly the lower box sections, with a system that does not depend upon ventilation to prevent corrosion. Previously, designers felt that ventilation would rid hidden areas of corrosive moisture and fumes; however, it was found that ventilation holes and louvers permitted the entry of dirt, water and salt-laden mud which dried slowly even with maximum ventilation and which ultimately attacked inside surfaces.

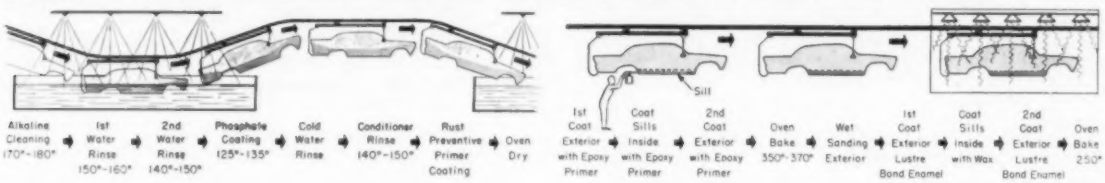
American Motors is now using a dip primer coating on all inside surfaces, plus an inhibited wax coating at critical inside spots such as the lower box sections. Trouble spots, such as inside fender-wheelhouse surfaces, are given an additional baked primer coat. Finally, the under-fender seams are heavily sprayed with asphaltic sealer and the whole wheelhouse area is then sprayed with a heavy layer of asphaltic sound deadener.

A quick look at the accompanying diagram will show the number of operations and the expense involved in corrosion-proofing today's cars. Chrysler's system incorporates seven separate immersion steps plus an oven dry before the first epoxy primer is applied. In addition, primer and a wax-type compound are applied inside the body sills. These materials are injected by pressure guns to insure that all hidden areas are adequately protected. The total system was developed after intensive artificial and on-the-road tests. Chrysler claims that it is "the finest and most effective rust prevention system ever offered for the preservation of U.S.-built passenger cars."

Car manufacturers are also adopting zinc-rich primers for special areas in both the unitized and the chassis-body types of construction. General Motors is using a zinc-rich primer on the insides of doors and many other hidden and critical areas. Also, areas inaccessible to priming

Rust preventive primer bath *used on Chrysler cars coats entire lower body up to a height of 18 in. This is final bath in anti-corrosion and rust-proofing system before body is sent through final painting operations.*

Complete sequence of operations *in rustproofing and painting Chrysler cars involves 17 separate steps.*



Materials that Auto Engineers Would Like to Have

- Metal-to-metal adhesives that will eliminate soldering, welding and mechanical fasteners.
- A substitute for expensive body solder.
- Materials that will completely eliminate the need for lubrication.
- A universal, multi-purpose lubricant that will take high temperatures and not attack seals.
- A low cost elastomeric seal that is not attacked by ozone, weather, and common solvents and hydrocarbons.
- An aluminum casting alloy that can be color anodized easily and cheaply. In general, coatings for aluminum fall short of needs.
- Better and more easily applied electroplates.
- Coatings that provide better resistance to corrosion. Coatings must permit weld-through (welding of galvanized metal is still a problem).
- A cheap coating that will resist rock salt corrosion (better still—find a substitute for rock salt!).
- Carpeting materials with better wear resistance.
- Stronger and cheaper plastics for high temperature applications.
- Better clear and scratch resistant plastics for dials and convertible rear windows.
- Cerametallic friction materials that will not squeal when brakes are applied.
- Carbon steels with better corrosion resistance.
- Low cost, high temperature alloys.
- Improved paints for plastics.
- A good clear coating to protect metals.
- A material as flexible and as cheap as vinyl but with 50° F greater heat resistance.
- Soft vinyl extrusions that do not pick up dirt on outdoor exposure.

after assembly, such as the insides of body sills, are coated with zinc-rich paint prior to welding.

General Motors and Ford are starting to employ galvanized steel extensively in many important areas. The Corvair uses 50 lb of galvanized parts, and plans are underway to use even more. And 85 lb of galvanized is being used in the Falcon for such diverse parts as rocker panels, rear rails and torque box, front rail extensions, and floor side members. Ford engineers estimate that galvanizing increases the life of parts to as much as three times that of conventional low carbon steel.

Paints are better

The average car owner gives a great deal of attention to the finish of his car and is particularly sensitive to its durability. Thus, paint specialists are constantly trying to develop longer-lasting and better-looking paints. The task has not been easy. A paint is expected to last the life of the car—and in all types of environments.

There is no question that remarkable strides have been made in recent years. Paint suppliers feel that the current acrylic lacquer system (used on GM cars) and the alkyd-melamine enamel system (used on Chrysler and Ford cars) are on a very high plateau. Continuing efforts are being made to improve corrosion resistance, but formulators feel that present finishes will last the life of the car if properly cared for. Although separate advantages are claimed for the lacquer and enamel systems, it appears that both systems have about equal durability and appearance.

Present enamel systems consist of a high melamine (30%) alkyd topcoat applied over a modified epoxy (see diagram). The high melamine content improves durability, especially with high metallic contents. The coatings are baked at 250 F. Dried thickness is about ¾ mil for the primer and 1.5 mil for the color topcoat.

The most important difference between the acrylic lacquer and alkyd-melamine systems is that the lacquer is applied to sanded undercoats and buffed to produce a characteristic satin sheen luster. In contrast the enamel has a harder-looking glossy appearance. Both systems are baked at the same temperature.

Paint specialists are taking a hard look at water-base paints. Tests show that they have good sanding and holdout properties and may offer better impact resistance. One manufacturer feels that the time is not far off when they will be used. However, other users note that shipping of the materials is a problem because of freeze-thaw conditions in winter. Also, their application is susceptible to weather conditions. Present solvent systems, unlike water-base paints, can be adjusted to meet varying humidity and temperature conditions during application.

Specialists are constantly searching for new color effects. Metallic finishes are quite popular now and it looks as though pearlescent finishes will be available shortly. Textured vinyl finishes have not gone over too well and probably will only be used on special order.

What Readers Think About Body Corrosion

Replies to almost 100 questionnaires show that most M/DE readers are not having body corrosion problems with their cars. But there are dissenters who say: "Bodies are very poorly preserved." See p 149 for more details on the reader survey.

4 The Gas Turbine Engine: Still a Hot Materials Problem

All three of the large automakers are working on the high temperature, efficiency and cost problems of the automotive gas turbine engine. Each company has a different approach, and the problems are different for cars than for trucks

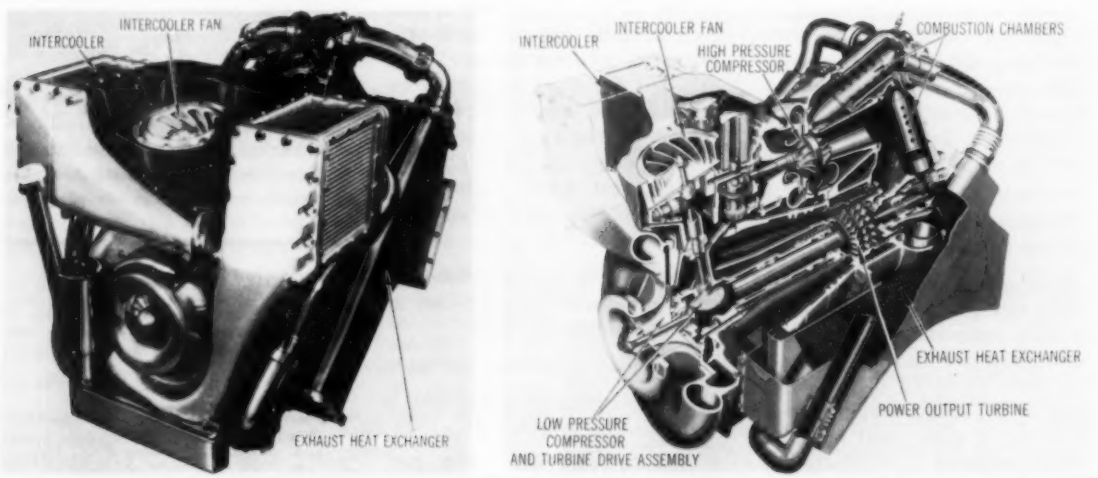
■ In discussing gas turbine problems a clear distinction has to be made between turbines for cars, and turbines for trucks, ordnance and off-the-road equipment. The problems created by both types of applications are similar, but their severity varies.

The high temperature problem—As is well known, the operating temperature of gas turbines is much higher than that of piston engines. Continuous temperatures of about 1800 F are encountered at the turbine wheels, and temperatures throughout the system are correspondingly high. Such high temperatures mean special high-priced alloys, and these alloys hold the key to the future of the gas turbine for automotive use.

Although a gas turbine weighs much less than a piston engine of the same power output (a typical gas turbine truck engine weighs 650 lb vs 3200-3500 lb for a comparable diesel engine), it still uses a substantial amount of high temperature materials. Thus, cost of the turbine is bound to be higher than for a cast iron or aluminum engine. Although this problem might not be a deterrent for truck engines (where higher initial cost can be tolerated), it is a serious problem for car turbines.

The efficiency problem—In order for a gas turbine to be efficient and provide good mileage it must operate at or near maximum torque. Thus, the gas turbine seems best suited for long distance trucks and off-the-road equipment operating continuously at high load. The engines are not very efficient when used in cars for stop-and-go city driving.

The capital investment problem—Because of their unique design, most gas turbine parts cannot be made on equipment now used for making car engines. Hundreds of millions of dollars are invested in this equipment and the automakers are not about to make obsolete such a large investment. However, the transition to gas turbines for trucking would not be as costly because capital investment is lower. Also, the advantages that gas turbines offer are more significant for trucks than for cars: 1) their high power-to-weight ratio permits greater payloads and profits; 2) the lower number of moving parts reduces maintenance; 3) time between overhauls is lower; and 4) less shifting, vibration and noise reduce driver fatigue.



Ford's new 300-hp gas turbine engine *weighs 650 lb installed—only one-fourth as much as a truck diesel engine of comparable power. It is approximately 38 in. long, 29 in. wide and 28 in. high. Under development for 2½ years, the engine has two stages of air compression.*

Current materials practice

As is to be expected, a conservative approach has been used in selecting materials for early gas turbine designs. However, now that design concepts have proved out and the engines look feasible for certain applications, we can expect to see a concerted drive to substitute less expensive materials for some of the exotic materials now used. Wide-scale use of the engines can only be accomplished if alloy content (particularly nickel content) of engine components is reduced. Experimental turbines built so far for military and automotive use contain too much alloy metal for quantity production.

For example, one 200-hp turbine built by GM contained 76 lb of nickel out of a total weight of 700 lb. The high proportion was used intentionally to remove any possibility of failure due to materials. However, it is reasonable to assume that continued development will reduce nickel content to 7.5 lb, and eventually even to 4.75 lb.

The GM approach—Experimental GM designs for the Firebird research cars have made extensive use of such materials as:

- Aluminized sheet steel: burners, turbine inlet and shrouds.
- 410 stainless: rim seals, bulkhead bolts.
- 321 stainless: outer seal bar.
- Aluminized valve steel: gasifier and pressure turbine nozzle vanes.
- Timken 16-15-6 (chromium-nickel-molybdenum alloy): gasifier and pressure turbine disks.
- GMR-235 (proprietary GM alloy): gasifier and pressure turbine buckets.
- Aluminum: compressor wheel, diffuser and housing.

Most of the materials are selected to resist corrosion at room or elevated temperatures. Sufficient heat resistance can be provided for many parts by using aluminized or chromium-bearing steels. However, a great deal of effort will be required to eliminate materials now containing substantial amounts of nickel, such as GMR-235, the 16-15-6 alloy, and valve steel operating in the 1300-1700 F range. Also, less costly fabrication techniques will have to be worked out.

According to GM, a free piston engine can be built with metals containing no nickel. In this engine the structure of the air chamber and compressor housing could be aluminum alloy for weight reduction, and pistons could be part cast iron and part aluminum to obtain proper weight for speed control. It is anticipated that conventional steels could be used for the cylinder sleeves and compressed air chambers and passages. The turbine would have rotor and stator blades of Silcrome 1 which contains only chromium (8-9%) and silicon in addition to iron. The case would be pearlitic malleable iron.

The Ford approach—Materials selection for Ford's new 704 gas turbine engine (see photos) has been largely governed by intended end-use—trucking, ordnance and off-the-road equipment. Ford believes that, because of cost problems, the gas turbine has little future for cars, but that it holds much promise for other applications. In Ford's words, "The gas turbine is a premium-priced engine and as such should be placed in a premium-priced product."

The 704 is a unique supercharged gas turbine of 300 hp and is one of the most outstanding gas turbines made to date. The materials used are admittedly exotic, but designers confidently expect that cost can be kept within reason. Because of conservative use of materials the engine has never experienced a materials failure. Briefly, the engine is now being made of:

- Hastelloy C (a molybdenum-chromium-tungsten-iron-nickel alloy): sheet metal scrolls.
- 410 stainless: exhaust diffusers.
- Inco 713 (a high nickel alloy): three turbine wheels.
- Nodular cast iron (6045-10): miscellaneous parts operating to 800 F.

A considerable amount of aluminum and small quantities of sheet metal are also used.

The Chrysler approach—Of the "big three," Chrysler is the most optimistic about the future of the gas turbine for cars. Its design philosophy resulted in early recognition that new, low cost materials would have to be developed if car turbines are to become feasible.

As publicized earlier (M/DE, Mar '59, p 4), Chrysler has developed two new heat resistant alloys whose low cost makes them promising for gas turbines. Composition of the alloys cannot be disclosed; however, it is known that they do not contain any critical materials. One of the alloys is especially suited for high temperature, low load applications. The other alloy is intended for use where both good oxidation resistance and strength are needed. The latter alloy resists oxidation above 2000 F and can be rolled, cast, forged and formed at normal temperatures.

Chrysler feels that it has made a significant breakthrough with these new materials. However, other manufacturers are skeptical. As one points out, several years are needed after the first development of a material to produce it cheaply in large quantities. Nonetheless, Chrysler believes that even though gas turbine materials are more expensive than piston engine materials, the lighter weight of the gas turbine engine will bring its cost down. Also, lighter engine weight will mean that other components of the car can be made smaller and lighter with consequent cost reductions.

Acknowledgments

This special report could not have been written without the complete cooperation of many people in the automotive industry. The author is especially indebted to representatives from:

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Ford Motor Co.
General Motors Technical Center
Saginaw Steering Gear Div., General Motors Corp.

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SILICONE NEWS

for design and development engineers • No. 79

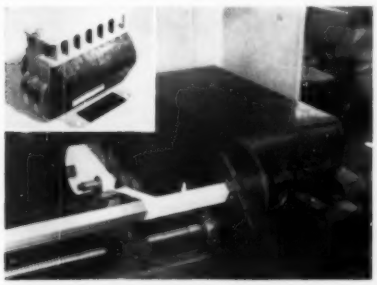
SILICONE RESIN HELPS MEET TOUGH SPECS

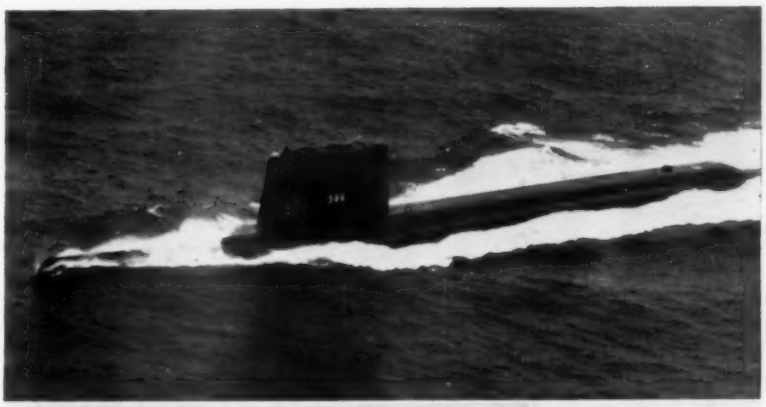
Solventless silicone resin helps meet stringent reliability requirements. Example: transformer start tubes manufactured by Osborne Electronic Corporation, Portland, Oregon.

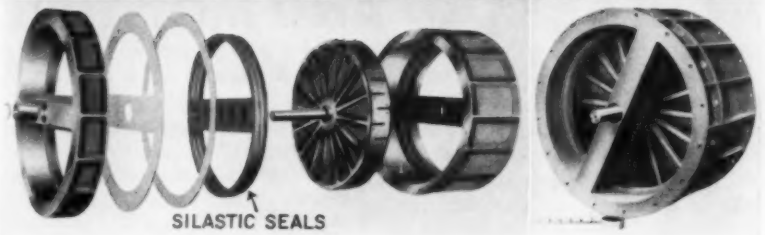
Osborne manufactures specialized high-performance transformers that are virtually standard equipment on major jets, such as the B-52, KC-135 and 707. To produce top quality start tubes of special sizes and shapes, Osborne engineers wrap glass tape on a mandrel, saturate it with Dow Corning solventless silicone resin, and then cure the tube form by heating.

These silicone-glass tubes meet all of Osborne's construction, performance and reliability requirements:

a. Retain mechanical and dielectric strength from —65 to 200 C . . . resist intermittent exposure to 250 C. *(Cont. Pg. 2)*







SILASTIC SEALS

DESIGN "THROUGH" SEALING PROBLEM

Silicone engineering materials often enable you to design "through" rather than "around" a problem. A heat exchanger manufactured by the Air Preheater Corporation, Wellsville, N.Y., provides a fine example.

Air Preheater makes rotary regenerative heat exchangers for atomic submarine air purification systems. When these extremely compact units are in operation, heat of the purified air pre-warms the stale air before it goes to the catalyst bed. Thus, the air entering the system is raised from room temperature to 575 F, and the purified air is cooled from 650 F to 175 F. This procedure, designed to aid efficiency, saves a combined heating and cooling load of about 70 kw.

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The Silastic foam cushion seal remains resilient in high temperature service; withstands compression loading created by rotor expansion; and has good resistance to friction and tearing action of the rotor. According to the designers, much of the success of the preheater can be attributed to the method of sealing. *No. 241*

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To obtain a copy of this engineers' reference — to learn how Silastic wire and cable insulation can help you design equipment that will perform longer and more reliably despite heat, cold, moisture, weathering, corrosive vapors, ozone and corona, circle . . . *No. 242*

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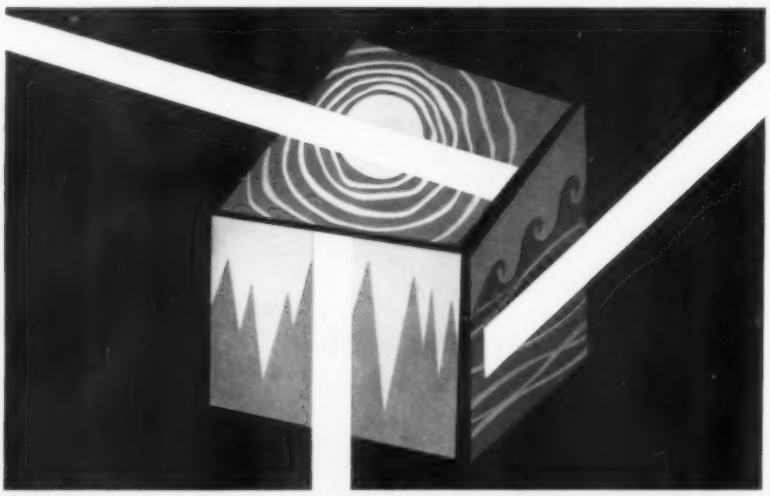

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• **On tapes.** Dow Corning silicone adhesives are used with most backing materials. Now readily available from several manufacturers are tapes with backings of glass cloth, Teflon, Mylar, aluminum foil, silicone rubber and combinations of these materials. Typical applications include: high temperature electrical insulation; bonding, splicing, and sealing; masking in chemical milling, and release surfacing.

• **Or alone.** For positive, dependable fastening in rugged service, some designers use silicone adhesives to seal heat elements in appliances, bond mica and asbestos panelboard, and bond silicone rubber to the coils of electrical equipment.

Dow Corning Silicones may well be your adhesive of the future. *No. 243*

SILICONE RESIN *(Cont.)*

b. Cure bubble-free without voids or pin holes. Easily applied by brushing, the solventless silicone resin penetrates completely and uniformly.

c. Readily withstand wire winding pressure without distorting.

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new literature and technical data on silicones

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Electronics Engineer's Guide describes all the silicone products that contribute to reliability, miniaturization and environmental protection of electronic components. From satellites to seismographic instruments, this 16-page electronics engineer's guide describes the various forms of silicones that help improve design. *No. 246*

Silicones in Appliances can give that extra edge for extra sales. This colorful booklet tells where and how silicones are being designed into appliances to give more efficient and reliable performance. Illustrations show how planning around silicones can make good products better. *No. 247*

Space Age Silicones are described in thirty typical application stories. Utilization of silicone compounds, fluids, lubricants, protective coatings, rubbers, resins, potting materials and sealants are illustrated for your consideration. This valuable brochure offers solutions to many problems encountered in designing space age aircraft and ground support equipment. *No. 248*

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FILE FACTS

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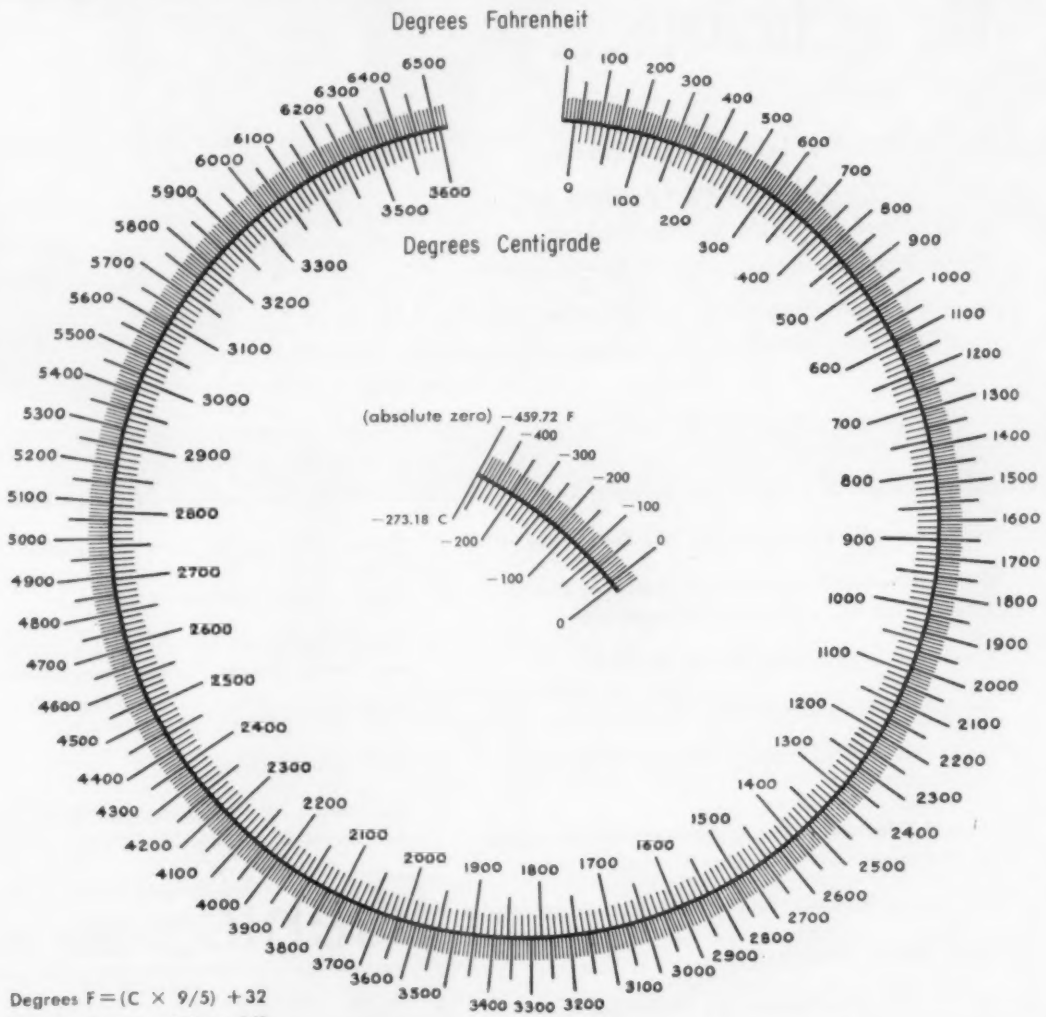

Degrees F = (C × 9/5) + 32
Degrees C = (F − 32) × 5/9

Courtesy: Fansteel Metallurgical Corp.

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MATERIALS AT WORK

...AT A GLANCE

A switch from beryllium copper to acetal plastic has resulted in an 80% decrease in the cost and a 16-fold increase in the life of an important component of a data processing machine. The part, called an interposer link, is a small device used to transmit impulses from a punched card into the electronic circuits of the machine. The part, which previously cost $630 per thousand and lasted for only 5 million cycles, is now injection molded for $120 per thousand and lasts 80 million cycles. Increase in the life of the part is attributed to acetal's excellent corrosion resistance, dimensional stability and vibration dampening characteristics.

Source: E. I. du Pont de Nemours & Co., Wilmington, Del.

Stainless steel has replaced aluminum for synchro motor housings because the error curve of the motor was found to be affected more seriously by temperature variations in aluminum housings than in stainless housings. A unit in an aluminum housing operating at 250 F, for example, deviated from its room temperature curve by a factor of 15 min. In the stainless housing, the deviation under the same conditions was only 1 to 2 min. The stainless housing also provides light weight without the problems of expansion and contraction.

Source: Daystrom, Inc., Murray Hill, N. J.

A bus with a reinforced plastics body is being given an experimental run by an English bus company. Except for the entrance steps, the entire body hull is made of glass fiber-reinforced polyester resins. Purpose of the experiment is to find out if worthwhile savings in building, maintenance and operating costs can be achieved. Advantages of reinforced plastics construction include quieter operation due to the nonresonant nature of the material, and greater comfort in hot and cold weather due to low thermal conductivity.

Source: British Information Services, 45 Rockefeller Plaza, New York 20.

Aluminum alloy 2219 has been selected for the fuselage of an improved Bomarc missile. The aluminum part, a combination fuselage section and fuel tank, consists of sheet welded to seven forged rings. Overall dimensions of the tank are 35½ in. in dia by 6 ft long. Aluminum alloy 2219 was specified because of its light weight, high strength and good weldability.

Source: Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh; Bomarc built by Boeing Airplane Co., Seattle.

Space travelers may 'spin their own cocoons' for emergency exits from malfunctioning space craft. The space traveler would be equipped with a space suit, an oxygen supply and a retro rocket. Over the space suit would be a plastic covering to which is attached a tank of plastic foam and mixer. On abandoning the craft, the man first fires the rocket to head him back to earth. He then inflates the plastic covering and fills the space with two types of foam: a dense foam for the heat shield and a sponge-like foam for a landing cushion. During re-entry, the dense foam would ablate and, in the atmosphere, a parachute would be released to slow the vehicle.

Source: General Electric Co., 3198 Chestnut St., Philadelphia 4.

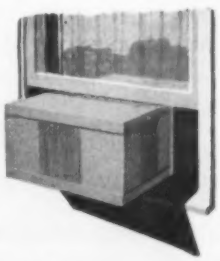
◀ For more information, circle No. 439

Better Products Through Better Methods and Steels

Above: unpainted air conditioner cabinet

How modern zinc-coated steel sheets keep air conditioners weatherproof—season after season after season.

When cold-rolled sheet steel formed the cabinets and special drawn base pans of air conditioners, they were primed and painted inside and out to protect them from constant exposure and functional moisture. Even so, corrosion often took hold around fastenings, louver edges and scratches.



Now that Weirkote continuous-process zinc-coated steel is used, the cabinet, louvers and chassis can be cut, bent and formed (even worked to the limits of the steel itself) without chipping or flaking the corrosion resistant zinc surface. When the outside paint finish is applied (primarily for decoration) the air conditioner has the double protection of a coating of paint and a coating of zinc assuring corrosion-free service for many years to come.

It's because of this weather-shedding surface, this superior formability that continuous-process zinc-coated steel is more and more the metal specified for air conditioning, heating and ventilating equipment.

A major supplier: Weirton Steel Company—producer of Weirkote continuous-process zinc-coated steel and many other steels that improve products, methods and profits throughout industry.

Look for the STEELMARK on the products you buy; place it on the products you sell.

WEIRTON STEEL
Weirton, West Virginia

Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

Weirkote will also be available in 1961 from National's Midwest Steel Division, Portage, Indiana

For more information, turn to Reader Service card, circle No. 460

Glass Beads Space Battery Cells

by J. Lynch, *Guidance Dept., General Electric Co.*

Glass beads and some ingenious equipment have solved a difficult problem in the design of spacers for sea water batteries used by the Navy to drive torpedoes.

The batteries consist of plates of silver chloride and a magnesium alloy stacked into cells. When sea water is circulated between the plates of the cells, the battery produces electricity to power the propulsion motor of the torpedoes. Purpose of the glass beads is to space the plates the proper distance (see accompanying sketch).

Specs difficult to satisfy

Specifications for the battery spacers called for resistance to chemicals, good electrical insulation, enough strength to withstand high compression forces, good heat resistance, resistance to absorption of moisture and resistance to deterioration when stored for long periods of time. In addition, the spacers could not restrict water flow and their height had to be controlled to within very close tolerances.

Glass beads only satisfactory material

Several materials were tried, but only glass beads satisfied all requirements. However, two problems remained:

1. Commercially available beads were mostly spheroids and the relatively few true spheres available varied too widely in diameter to be useful. Acceptable beads could be hand sorted, but literally billions would be needed.

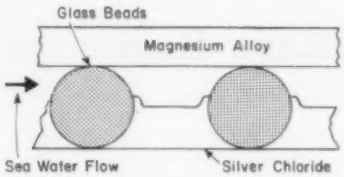
2. Even if suitable beads were available, there was no practical way of putting them in place and keeping them there.

These problems were solved by the joint efforts of Bell Telephone Laboratories and the General Engineering Laboratory of General Electric Co.

Sorting problem solved

Ingenious equipment, consisting of a vibratory table that sorts for sphericity and roller sieves that sort for diameter, were devised. Unsorted beads are first fed to an inclined and

Sergeant missile launcher's weight has been cut 7000 lb by substituting T-1 steel for standard. Light gages of flat rolled sections are used in the U frame, extension arms, outriggers, tension members and back beam of the 16,000-lb, air transportable vehicle. Welded pipe is also used in the torus ring of the superstructure. U.S. Steel says that T-1 has a yield strength of 100,000 psi and can be welded and repaired in the field.



***Battery plates** are spaced proper distance by spherical glass beads.*

vibrating table. Under the action of the vibrations, the beads move slowly toward the opposite end of the table. However, the spherical beads react to the sideways tilt of the table and tend to roll to one side of a barrier. Imperfect spheres do not roll as freely; their paths tend to be straighter and they pass on the other side of the barrier.

The sorted spherical beads are then gravity-fed to a series of roller sieves that sort out all but those of the desired diameter.

To place the beads between the plates presented another problem: there are 64 beads in every square inch of cell area, or a total of 6 million beads per battery. Since silver chloride is about as soft as lead, it was found that the beads could be fastened by simply forcing them into the plates. Special equipment developed to perform this function provided tolerances of ±0.001 in. on the height of the impressed beads.

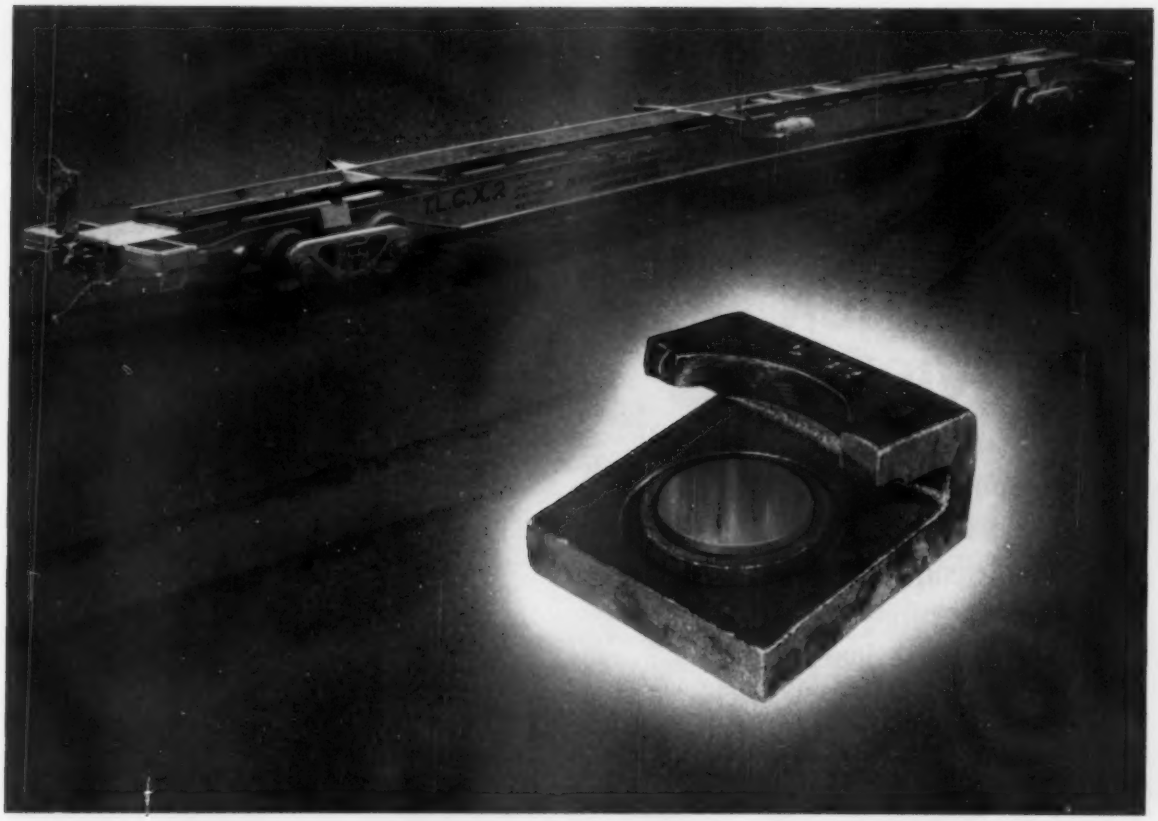
Jet Thrust Reverser Uses Welded Tubing

Light weight, high strength and ease of fabrication are the reasons given for the selection of tubing, in preference to other forms or shapes, for jet engine deflector vanes.

The deflector vanes direct jet engine exhaust gases for thrust reverser braking in a new General Electric commercial engine now being used on Convair 880 jet liners. The vanes perform the same function as reverse pitch propellers on piston-engine planes, i.e., they reduce landing speed and hence permit jet aircraft to land on shorter runways.

Stainless, superalloy tubing

The major portion of the reverser vane, the part that actually directs the jet blast, is fabricated from air-



Non-lubricated anti-friction pads of TEFLON® cut bearing costs over 80% on railroad cars

On a newly designed railroad car, I-beam frames that support cargo containers ride on anti-friction pads of a filled TEFLON TFE-fluorocarbon resin. Thirty bearings, like the one shown above, permit forward and backward movement, which cushions the containers against impact. Each complete bearing of TEFLON with metal backing costs about $1.75, less than one-fifth the cost of a 5″ roller bearing which would otherwise be used. In addition, the low-friction pads of TEFLON make lubrication unnecessary . . . while maintaining low break-away friction. The absence of grease prevents sticking of abrasive dirt from track bed on the bearing surface.

If *your* equipment designs involve journal, plane-surface or thrust bearings, consider the money-saving advantages offered by bearings of TEFLON. Filled compositions and reinforced constructions of TEFLON resins are available to meet the requirements of increased loads and speeds or of high wear resistance—and TEFLON fluorocarbon resins provide dry lubrication.

For more information about design improvements and cost savings made possible by the use of TEFLON, write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department T-26, Room 2526, Nemours Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resin.

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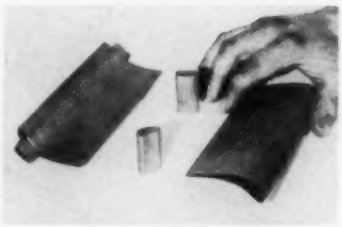
MATERIALS AT WORK



***Airfoil-shaped stainless steel** deflectors (right), HS-25 superalloy trunnions (center) and complete vane (left).*

foil-shaped welded type 321 stainless steel tubing. Brazed to these sections are short lengths of HS-25 welded tubing. These short lengths act as trunnions or hinges for vane positioning. Although HS-25 is generally thought of as a high temperature superalloy, in this case it was selected primarily for its excellent wear resistance.

The airfoil shape of the vane is formed in three separate operations from 1¾-in. o.d., 0.028-in. wall tubing in 5½-in. lengths. The final forming operation uses a three-piece mandrel inserted in an enclosed die. Tolerance requirements on the part are ±0.020 in.

The short trunnion pieces are formed from smaller tubing: ⅝ in. o.d., 0.063-in. wall and 1⅛ in. long. Tolerances on this part are kept to ±0.004 in.

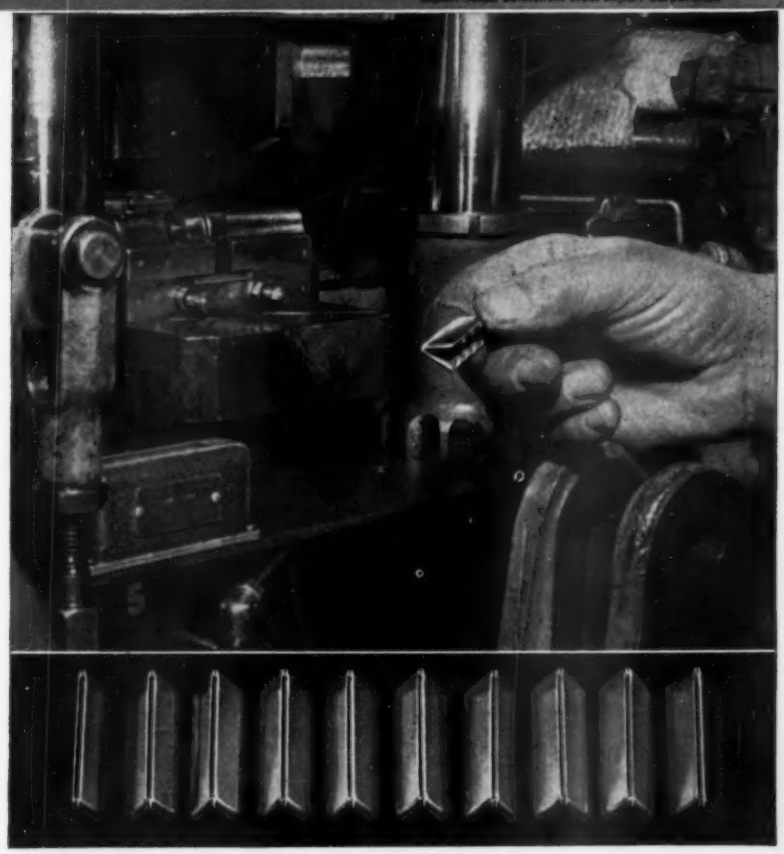
Efficiency improved

In operation, engine thrust is reversed by clamshell doors that close behind the engine proper. The reversed exhaust gases are then directed forward by a series of deflector vanes which can be rotated (on the HS-25 trunnions) to accu-

***Installed deflector vanes** are shown on exterior of engine pod.*

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation



Lehigh H blanks and forms 1,000,000 pieces before redressing is necessary

Using a die of Bethlehem Lehigh H tool steel, Sobel Metal Products Co., Easton, Pa., produced this nickel-silver belt accessory, of the type used with army uniforms, at the rate of about 1,000,000 pieces before redressing was necessary. Blanking and forming .020-in. metal, the die was hardened to Rockwell C60-61. One of the requirements of the order was that no marking was permitted on the finished part.

Lehigh H (AISI D-2) is excellent tool steel for jobs like this. Not only is it the leader in machinability among the high-carbon, high-chromium tool steels sold today — it also has improved wear-resistance because its vanadium content has been increased to 1 pct.

As the result of a new manufacturing process, Lehigh H has improved carbide distribution and increased center density. It also has minimum distortion during heat-treatment.

If you want unexcelled machinability, excellent wear-resistance, and plenty of dependability, Lehigh H is your answer. See your Bethlehem tool steel distributor for prompt delivery.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Blind Holes Can Cause Plenty of Trouble

Unless one uses great care, blind holes can cause a lot of trouble when heat-treating tools. Holes for studs or dowel pins are typical of the blind holes which, as a rule, are paid little attention. Exposing blind holes to liquid quenching produces extremely high internal stresses, which can lead to cracking of the tool, either during heat-treatment or in service.

If it is not necessary for blind holes to be hard internally, these difficulties can be avoided by packing the holes prior to the quench, using clay, asbestos rope, steel wool, or a steel plug.

Blind holes are particularly objectionable if they must be uniformly hard on the inside surface. The only way to meet this requirement consistently is to select a grade of air-hardening tool steel.

Be Sure to Try Red Sabre Tool Bits

You're sure of economical cutting when you use Bethlehem Red Sabre Tool Bits, regardless of the type of application. Red Sabre is a super high-speed steel, with about 1.50 carbon, 12.00 tungsten, 5.00 vanadium, and 5.00 cobalt. The bits have high red-hardness and uniform hardness all the way through, for peak resistance to wear and maximum cutting ability. They come hardened to Rockwell C65.

For more information, turn to Reader Service card, circle No. 343

rately control the forward component of thrust.

According to Standard Tube Co., the welded stainless and superalloy tubing add significantly to the thrust reverser efficiency. Performance tests have produced reverser thrusts of 5400 lb (more than 45% of rated forward thrust) in less than 1 sec with a loss in engine efficiency of less than 1%.

Porcelain Enamel Outlasts Epoxy, Zinc

Results of salt spray tests conducted on three different materials have led to the selection of a porcelain enamel coating for blower wheels used in process equipment, air conditioning equipment, cooling towers, evaporation condensers, air washers and other equipment subject to corrosion and/or abrasion.

The three coatings tested were: an epoxy finish, a galvanized coating and the porcelain enamel.

The epoxy-coated wheel (a cold rolled steel phosphatized and painted with an epoxy-resin finish) began to rust after only 24 hr. After 168 hr, there were strong signs of rust. And after 1000 hr, the wheel was badly rusted.

The galvanized wheel began to show surface changes (zinc chloride) within 24 hr. After 168 hr, rusting began to show. And after 1000 hr, the zinc coating had peeled and rusting was severe.

The porcelain enamel wheel showed

Morrison Products, Inc.

***Porcelain enameled** wheel (top) showed only minor traces of rust after 1000 hr; epoxy-coated wheel (lower left) and galvanized wheel (lower right) were severely rusted.*

SIMPLIFY LOW-TEMPERATURE SILVER BRAZING WITH THESE SPECIALLY DEVELOPED FLUXES!

The correct selection of flux can offer unexpected help in speeding and simplifying production, minimizing rejects and lowering costs in low temperature silver brazing operations. The advantages to be gained by "selective fluxing" are *sufficiently important to warrant careful, thorough study!*

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Call the Silvaloy distributor in your area for consultation and detailed information or, send for our booklet "A Complete Guide to Selective Fluxing for Low Temperature Silver Brazing."

Silvaloy fluxes are packaged in 65-lb. and 30-lb. drums, 5-lb. wide mouth jars (5 to a carton), 1-lb. and ½-lb. jars. The wide opening of the 5-lb. package makes it a most practical, time saving dispenser that also enables the operator to make use of every bit of flux in jar.

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no rust at all for the first 120 hr. A few rust spots began to appear on the blades after 168 hr. But there were only slight traces of rust after 1000 hr, most of which were easily wiped off.

Stainless Tubing Cools Generator

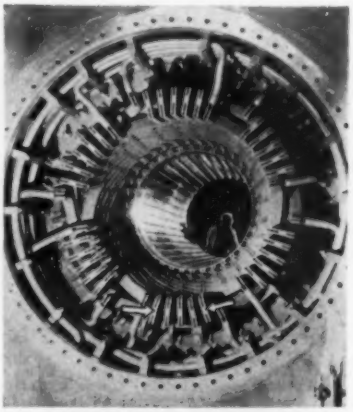
Thin-walled rectangular stainless steel tubing has been specified for a hydrogen gas cooling system used on a fully-supercharged steam turbine generator.

According to Carpenter Steel Co., removing heat by using cold hydrogen gas within the major insulation of current-carrying conductors is an old idea. But it has only recently been successfully applied to turbine generators.

Type 304 stainless steel tubing was selected for the hydrogen coolant path for a number of reasons:

1. A nonmagnetic material was needed to avoid excessive heating caused by an extremely strong alternating magnetic field.
2. Low eddy current loss.
3. Its strength permits use of thin-walled tubing, allowing more room for copper in the stator coil and maximum possible gas space within the tubes. Also, thin-walled tubing is easy to bend.

Rectangular tubing was specified to conform with the coil construction in the stator and to provide maximum surface for heat transfer.



***End openings** of rectangular tubing are visible in assembled coils.*

ECONOMY, DURABILITY AND DEPENDABILITY are outstanding characteristics of these sintered metal gears. Parts like these are the result of close cooperation between Delco Moraine and its customers from idea through design and development to production.

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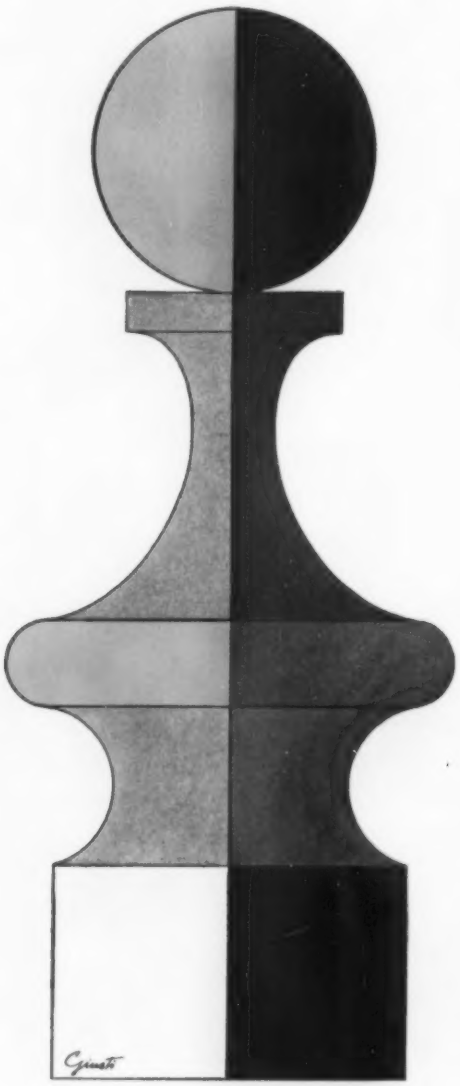

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Western BRASS

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(cont'd from p 142)

Heater Simulates Re-Entry Blast

A high-energy electric arc heater with immediate application in wind tunnel tests for missiles has been devised by Westinghouse Electric Corp. Nozzle temperature has been maintained at 10,000 F—approximately as hot as the surface of the sun, and flow from the nozzle has reached 3400 mph.

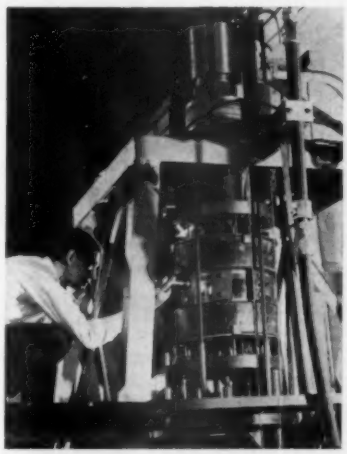
Chemical, metal uses

Westinghouse says that the heater can supply a gas stream at temperatures up to 20,000 F and pressures as great as 15,000 psi for sustained periods of time and at an extremely low level of gas contamination. For these reasons it holds promise as a chemical synthesizer and as a furnace for metals with ultra-high melting points. For example, it might make a number of refractory metals available in ingot form for the first time.

How the heater works

The basic concept of the new heater is use of an electric arc, dissipating 1700 kw, to continuously transfer energy to a gas passing through it. Each of the two electrodes is a hollow ring, placed horizontally, one directly above the other. A water coolant is pumped through the rings.

An electric arc is started by drawing it across the gap, and then rotated around the gap at high speed by a moving magnetic field. This rotation, plus the cooling action of the water, prevents the electrodes from overheating to the point where they deteriorate or burn and contaminate the reaction.



***Electric arc heater** showing the magnetic field coils above and below the chamber. Upper and lower electrodes can be seen inside the transparent chamber wall.*

Corrosion of Polyesters Varies

Tests under way at Atlas Powder Co., Wilmington, Del. show that wide differences exist in the corrosion resistance properties of various polyester resins.

Three resins tested

In the tests, castings and laminates made from three different polyester resins—bisphenol A, isophthalic and general purpose—were immersed in corrosive solutions for periods ranging from 24 hr to 90 days, and changes in physical properties noted. The corrosive media were distilled water, 5% sodium hydroxide, 5% nitric acid, 25% sulfuric acid, 15% hydrochloric acid, 25% acetic acid, Clorox, and 5% Electrosol, a commercial dishwashing detergent.

Screening test ineffective

One significant finding was the ineffectiveness of a fast screening test used. In the screening trial, castings made from the three resins were subjected to boiling sulfuric acid, distilled water and sodium hydroxide for 24 hr. It was found that a resin might withstand the screening test satisfactorily, but would not hold up

ENGINEERING & DESIGN

after longer immersion periods. For example, the isophthalic resin, which appeared satisfactory after 24-hr immersion in sodium hydroxide solution at 210 F, completely deteriorated before 30 days at 210 F.

Other results of the tests:

1. After a 90-day exposure test, none of the bisphenol A polyester specimens were deteriorated appreciably, with the exception of a casting immersed in nitric acid.

2. The general purpose polyester resin was seriously affected or completely deteriorated by all of the corrosive media.

3. All isophthalic specimens suffered serious or complete deterioration, except those immersed in sulfuric acid and Clorox solutions.

4. Electrosol detergent completely deteriorated both the isophthalic and general purpose polyesters after one month immersion. Bisphenol A polyester, on the other hand, retained 50% of its original flexural strength after 90 days.

5. Sodium hydroxide attacked both the general purpose and the isophthalic polyesters, and both lost all of their original flexural strength before the end of a 30-day test period. Bisphenol A polyester, however, retained almost 60% of its original flexural strength after three months exposure at 210 F.

Polyesters should be selected according to specific type

According to S. S. Feuer, of the company's Chemicals Div., the test results indicate that designers and fabricators of corrosion resistant equipment should select a polyester resin according to specific type and not under the general term "polyester."

How Radiation Affects Leather

The increasing use of nuclear power and the possibility of achieving manned space flights has prompted scientists and engineers to learn more about the effects of radiation on various engineering materials.

An up-to-date report on how radiation affects engineering materials was presented in the July issue of this magazine (p 119).

Recent research at Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio has provided information on the effects of: 1) gamma radiation on leather; and 2) charged particles on space craft materials.

1. Leather

Since leather gaskets and washers may come in contact with a radiation source, V. G. Vely, N. D. Gallagher and M. B. Neher of Battelle investigated the effects of gamma radiation on vegetable-tanned, chrome-tanned and retanned leathers, and on pickled calfskin. The research showed the following:

1. Radiation has a detrimental effect on all four materials as indicated by decreases in shrinkage temperature, breaking strength and elongation. Shrinkage temperature was recorded as the temperature at which specimens contracted a minimum of 0.005 in. The greatest damage occurred when specimens were exposed to 10^8 reps (roentgen equivalents, physical) of irradiation.

2. Vegetable-tanned leather showed a greater decrease in shrinkage temperature, but a lesser decrease in breaking strength than chrome-tanned and retanned leathers.

3. Pickled calfskin was adversely affected by 10^7 reps irradiation as indicated by significant decreases in shrinkage temperature and breaking strength.

4. Irradiation did not cause nontanning organic compounds to exert a tanning effect in pickled calfskin. Moreover, some nontanning organic compounds appeared to increase radiation damage in pickled calfskin. Glutaraldehyde, possibly because of its tanning ability, decreased the severity of radiation damage in pickled calfskin.

2. Space craft materials

Since 1957 instrumented space vehicles have provided voluminous data about newly discovered concentrations of charged particles that are earth-oriented. These concentrations are called the Van Allen belts after Dr. James Van Allen of the State University of Iowa.

Basically, it is believed that the charged particles in these belts, including protons and electrons, are secondary emission particles that are trapped in the earth's magnetic field. The inner belt appears to be relatively stable and is probably formed from the interaction of primary cosmic particles with atoms of the atmosphere. The outer belt

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RESISTANCE TO CHEMICAL ATTACK—GRAPHITAR has the ability to withstand the action of almost any chemical, with the exception of the most highly oxidizing re-agents in hot and concentrated form. GRAPHITAR parts, for example, operate efficiently in steam, chemical and gas valves to provide a corrosion resistant material operating under the most adverse conditions.

MECHANICALLY STRONG—GRAPHITAR will not warp or distort even in high pressure applications. Compressive strength up to 45,000 psi and transverse breaking strength from 3000 to 16,000 psi, depending on the grade.

HEAT RESISTANT—GRAPHITAR is not affected by heat under neutral or reducing conditions. Temperatures of oxidation for most grades is approximately 700 degrees F. In addition, GRAPHITAR engineers have developed a special oxidation resistant grade of GRAPHITAR that has been exposed in an oxidizing atmosphere (air) of 1200 degrees F. and after 200 hours, it showed a weight loss of less than six per cent.

MOLDABLE—GRAPHITAR has excellent moldability properties that make possible and practical unusual shaped parts. Design requirements such as ears, face slots, and outside diameter notches can easily be incorporated into GRAPHITAR parts without secondary machining and finishing operations.

MACHINING—The United States Graphite Company operates an excellent finishing department to do all finishing operations to the most exacting specifications. GRAPHITAR may be ground to size or shaped with a tungsten carbide or diamond tipped tool to tolerances as close as .0005". When surfaces require a high degree of precision in flatness, lapping and polishing equipment are employed and accuracies within three light bands can be produced.

LIGHT WEIGHT—GRAPHITAR is lighter than magnesium and is being employed increasingly in the aircraft and missile fields. The weight per unit volume of various GRAPHITAR grades is as follows: 102.8 to 116.03 pounds per cubic foot, .0595 to .0672 pounds per cubic inch, .952 to 1.074 ounces per cubic inch.

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R-284-1

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is not stable, and is believed to be formed from some unknown reactions with solar radiation.

Since space vehicles are likely to operate or travel through the Van Allen belts, R. F. Badertscher and R. E. Hess of Battelle made a literature survey to determine how well space craft materials would stand up in these belts. Here's what they found:

1. For comparative purposes, metals in a space craft would probably be able to operate for many centuries in the Van Allen belts before reaching their threshold of damage.

2. Although elastomeric compounds and organic fluids have the lowest threshold of damage of all space craft materials, most elastomers and organic fluids could probably be exposed to radiation in the Van Allen

Mobile hardness tester—The direct-reading hardness tester shown here has been designed for conducting Rockwell hardness tests on large or bulky metal parts that cannot be moved to a testing station. The tester, developed by Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn., can also be used in tool departments, maintenance repair shops and inspection departments. The unit's minor and major test loads are produced by springs that are preloaded and contained in an individual spring sleeve. Complete spring units are interchangeable for different load ranges.

An example of Avisco Rayons in Industry

Now, stronger, lighter-weight belts with Avisco XL-I rayon

Because of fabrics made from Avisco XL-I rayon fiber it is now possible to engineer stronger, lighter-weight belts.

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belts for a year before reaching their threshold of damage.

3. Electronic components such as vacuum tubes, capacitors, transformers, insulating materials, relays and switches would not be damaged by radiation in the belts unless exposed for long periods of time.

4. Semiconductor materials are also relativcly resistant to radiation encountered in the belts, but long time exposures in the belts would be harmful.

Copper Ups Endurance of High Strength Steels

Copper improves fatigue strength of high strength steels, according to the results of tests conducted by H. E. Frankel and J. A. Bennett of the National Bureau of Standards, and C. M. Carman of Frankford Arsenal.

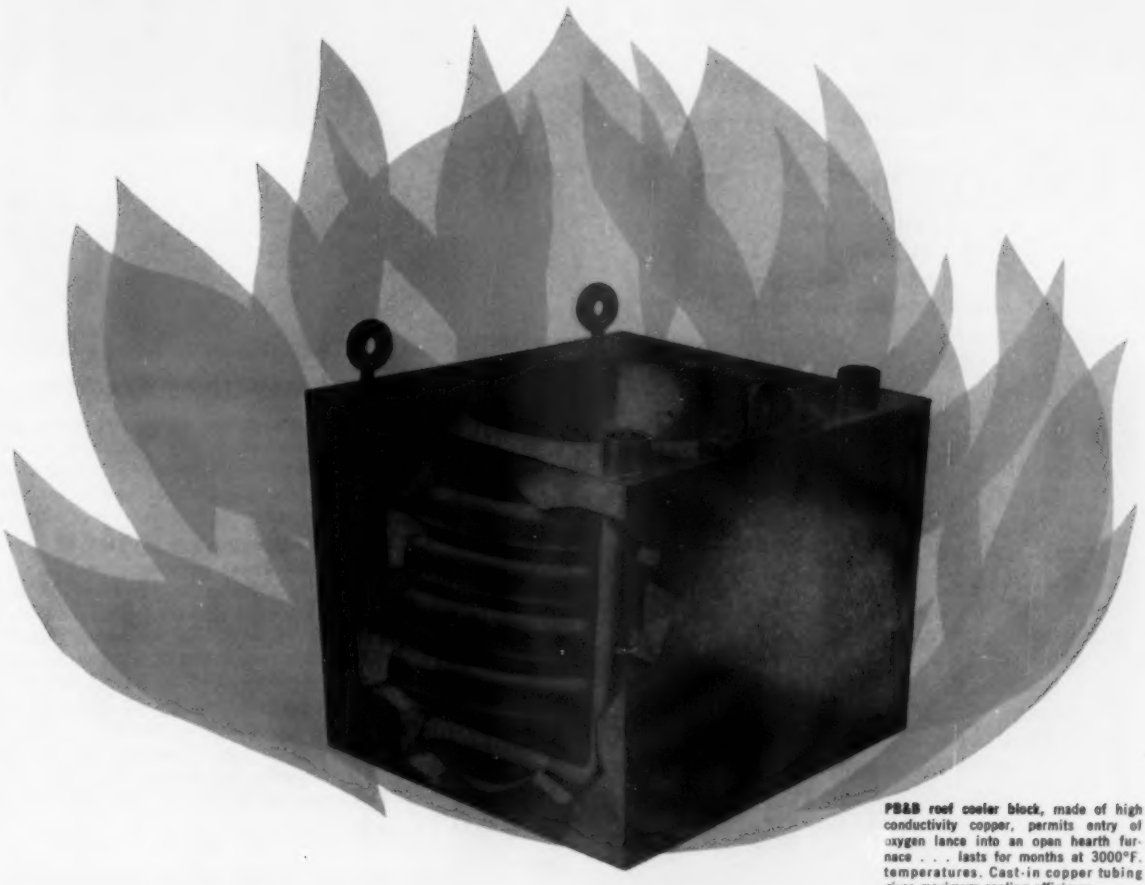
The three men, who conducted fatigue tests on over 350 specimens taken from 18 different steels, found the following:

1. Copper-containing steels, when tempered at 350 or 400 F, had higher maximum fatigue strengths as well as greater fatigue strength-yield strength ratios than any other material tested.

2. The superior fatigue properties of the copper-containing materials are probably caused by the precipitation of copper under the influence of fluctuating stresses. The amount of copper in the alloy is critical, with 1.3% copper by weight giving optimum strength when low tempering temperatures are used.

3. Some of the copper-containing steels showed a marked tendency to start subsurface fatigue cracks. Of 32 specimens taken from four steels that had the best fatigue properties, 21 had cracks originating below the surface. Specimens of all the other materials developed normal fractures with the crack nucleus on the surface.

4. A previous study showed that increasing carbon content in steels requires higher hardness to attain equivalent fatigue strengths. Although specimen preparation was different in the present study, the same general tendency was noted: in steels of similar composition there



PB&B roof cooler block, made of high conductivity copper, permits entry of oxygen lance into an open hearth furnace . . . lasts for months at 3000°F. temperatures. Cast-in copper tubing gives maximum cooling efficiency.

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At temperatures where most metals soften or melt, high conductivity copper often can outlast other materials. But—it takes special techniques to make copper live in extreme heat. We have a wealth of experience in this field; here's what we can do for you when you need cast or forged copper components for high temperature duty.

MAXIMUM COOLING IS ESSENTIAL. We have developed methods for casting copper cooling tubing in place in high conductivity copper, to obtain maximum heat transfer.

HIGHEST CONDUCTIVITY COPPER. All copper is not alike: most copper castings have a conductivity of less than 70%, sometimes going as low as 25%, and do not give efficient heat transfer. For castings, we use virgin electrolytic copper guaranteed at least 90% IACS conductivity. Our forgings are made of OFHC* copper, and are guaranteed at least 98% IACS conductivity. Where high strength as well as conductivity is required, we supply alloys of copper . . . chrome, beryllium, zirconium . . . in castings and forgings.

PROCESSING AND TESTING. Our castings and forgings are processed using special techniques developed by us to assure highest possible conductivity. Every piece is checked on a magnatester and its conductivity is individually certified.

We will welcome the opportunity to discuss how high conductivity alloys . . . produced the PB&B way . . . can solve your high temperature problems. Call or write for a consultation.

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Call on us for high quality, prompt delivery on castings and forgings of high nickel alloys for extreme temperature service:

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is a decrease in the fatigue strength-yield strength ratio with increasing carbon content.

Steel Parts Made Accurate by Freezing

Low temperatures are being put to use at Boeing Airplane Co. to produce accurate aircraft parts made of precipitation-hardenable stainless steels (17-7 PH and PH 15-7 Mo).

Freezing becomes part of heat treat process

Specifically, a machined, formed or welded part is heated to 1725 F as part of the hardening process. This may result in warping or other distortions. The part, cooled to slightly above 200 F, is forced into a sizing die prewarmed to 200 F, and held by clamping, banding and wedging, or simply by the pressure of the die itself. Part and die are then cooled gradually. Final cooling, to as low as –110 F, is done in a solution of dry ice and trichloroethylene, or in a dry cold box.

Steel reforms during cooling cycle

At some stage during the cooling cycle a metallurgical transformation takes place: the crystalline structure of the metal changes and molecules of carbon and iron realign themselves to form new and permanent alliances.

During this transition the metal is believed to be momentarily pliable. The steel reforms in the precise dimensions to which it is being held at the time.

When a part is removed from the dies, the tendency to warp or spring back no longer exists. The part shows a close fit to design dimensions and usually can be furnace aged to higher strengths without the use of a restraining fixture.

Method called cryoforming

The process, called cryoforming, sizes warped or sprung parts to within 0.0013 in. per in. on a 5-in. part. In one case, welded and machined T-shaped external attachment members for brazed panels

Based on an article by Judson Hubbart, appearing in the Feb '60 issue of *Boeing Magazine*.

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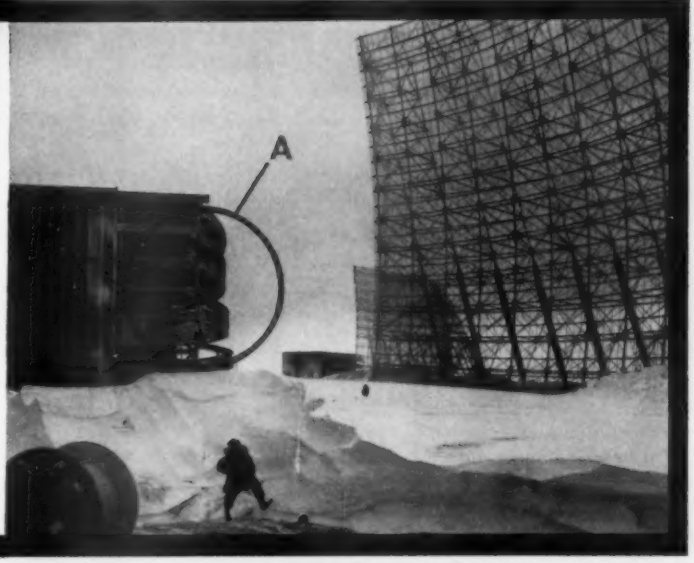

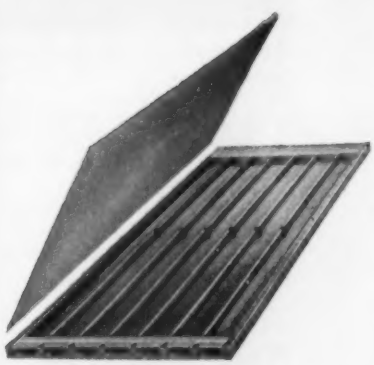

Radar Window of G-E TEXTOLITE 11546 protects exposed feedhorns (A) while permitting transmission of radio frequency energy. Hot air continually blown through window cells prevents ice formation during sub-zero arctic weather.

Towering high over the Arctic wasteland, giant radar antennas like this one (each larger than a football field) form part of the surveillance radars for the U. S. Air Force's Ballistic Missile Early Warning System (BMEWS). Developed by G-E's Heavy Military Electronics Department for RCA, BMEWS prime contractor, these surveillance radars will be instrumental in providing approximately a fifteen minute warning in case of a missile attack across the northern polar region. The first of three BMEWS sites is nearing completion near Thule, Greenland.

So gigantic is this surveillance radar that feedhorns and other vital equipments are housed in separate scanner buildings. Protecting each feedhorn from the sub-zero arctic weather is a Deicer Panel Assembly or "radar window" fabricated from G-E TEXTOLITE 11546, a G-10, high IR, glass epoxy laminate.

Micarta Fabricators Inc., an independent Chicago fabricator, built the windows for the Andrew Corporation who had the overall responsibility for the feedhorn-window system. Andrew specified TEXTOLITE after conducting a development program to select the most suitable material consistent with low cost. Tests prove TEXTOLITE 11546 meets the rigorous electrical, mechanical and environmental (−70° to +50°F, temperature variations, winds up to 185 MPH) conditions inherent in the BMEWS project.

For information on 11546 or other G-E TEXTOLITE laminates for your particular application requirements write: Laminated Products Department, Section MD-110, General Electric Company, Coshocton, Ohio.

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Final cooling *of stainless steel part is done in a solution of dry ice and trichloroethylene.*

After cryoforming, *parts can be furnace aged to higher strengths without a restraining fixture.*

were held to ±0.002 in. for each 12 in. of a 36-in. member.

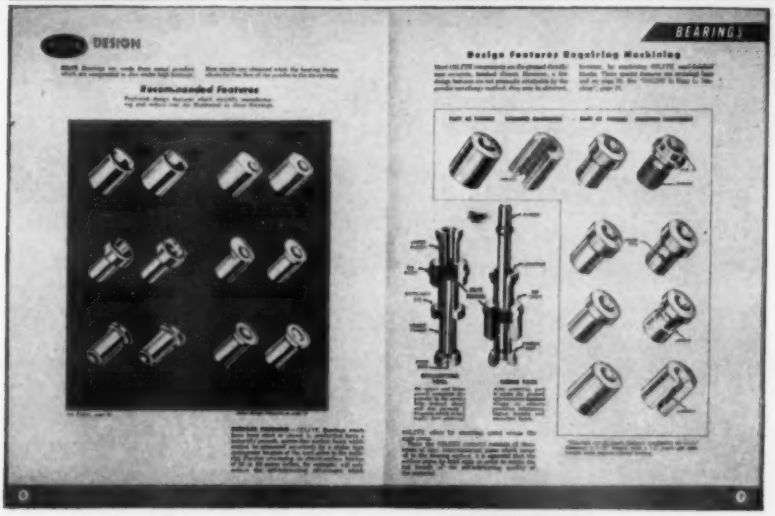
The method was devised by Boeing manufacturing research engineers C. Jung, L. Albertin and C. Bennett.

Weathering Confirms Chromium Plate Tests

Results of outdoor exposure tests in Detroit and in a seashore atmosphere over the past year confirm the results of accelerated laboratory tests of plated chromium samples.

According to Metal & Thermit Corp., both test methods show that superior protection is provided by thicker coatings, such as crack-free and duplex chromium applied over bright nickel, compared to standard chromium specified in the past (see M/DE, Sept '59, p 136).

POWDER METALLURGY ENGINEERING MANUAL



HOW TO determine the correct applications for self-lubricating bearings and powder metal parts. **Bearing** section includes: design features, computation of loads and speeds, calculating nominal dimensions, examples of designing for both new and existing applications —plus stock list of 1050 standard Oilite bearings. **Powder metal parts** section includes: typical properties, materials selection guide, design features, magnetic properties, information request form.

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TECHNICAL LITERATURE

(cont'd from p 51)

Books

A History of Metals (in Two Volumes). *Leslie Aitchison. Interscience Publishers, Inc., New York. 1960. Cloth, 8¾ by 11½ in., 685 pp. Price $30*

Reviewed by Donald Peckner *

Even the most outspoken critics of engineering and engineers cannot help but be awed by the achievements discussed in these two volumes. Dr. Aitchison performs the creditable task of weaving the history of metals against the backdrop of the history of man.

In the beginning, the nomadic nature of the peoples, the wars, the scattering of the population—all helped to both advance and hinder the advances made in the metals field. Skills were closely guarded and could advance only as the workers themselves migrated to other regions.

Knowledge, therefore, could be a common heritage in one region while it was unknown in adjoining regions. Because of this, the early history of metals was a local one which makes dating and speculation concerning the first three thousand years or so quite difficult.

What this book does is present a unified story of how knowledge of metals and metalworking progressed over the millenia. The author is a metallurgist with an obviously wide knowledge of history. We read the two volumes with a feeling that here, for the first time, is a unified gathering of information and speculation concerning the material which is the backbone of our civilization.

Author discusses first metals used by man

In the first volume, Dr. Aitchison discusses the emergence of the first seven metals with which men worked. The first metals used were gold and native copper beginning, perhaps, 7000 years ago. Copper smelting was probably not discovered until perhaps 4000 B.C. The old saw that metal was first discovered in the remains of a hunter's campfire, by the way, is effectively destroyed by the author in just one page. From experiments conducted on monazite, a copper-bearing ore, it is obvious that no campfire was hot enough to separate the metal from the ore. The most that could be expected from such a crude hearth would be an oxidized piece of copper, unrecognizable from the other coals in the fire, or a fine copper oxide. Smelting of copper was probably associated with the development of furnaces to fire pottery, as well as the development of ornamental glazes which used a cupriferrous ore as an ingredient. Should a piece of monazite ore have been left in the glazing oven it would have been reduced to copper in a recognizable form.

After copper and gold, lead, silver, tin, iron and mercury were successively found and used. Bronze was developed, displaced copper, and was in turn displaced by iron. A way to carburize iron was invented and this alloy along with brass, soft solders and pewter completes the list of metals used until approximately 1000 A.D.

Metallurgical industry emerges

With the second volume, we begin to see the development of a metallurgical industry as well as continuing artistry. Power other than human muscle power is applied to metallurgical operations for the first time, enabling changes and improvements to be made in the ways of producing the old metals and alloys.

The revolution in the modes of philosophical and scientific thinking which occurred at the end of the Middle Ages opened the way to the discovery of new processes for extracting metals from their ores and minerals, and the number of alloys that could be made.

Science even has created metals not found in nature—the transuranic elements ranging upward from atomic number 93.

Antiquities illustrated

The story presented in this British book is delightful reading for all who have an interest in metals.

One can take pleasure in browsing through the pages: the illustrations alone are well worth the cost since they bring to the American reader well-reproduced views of antiquities collected by the British museums—items that are not generally available to us. If you are interested in how the use of metals developed with man, then this is a book which can be highly recommended. It is a book which can be read and reread without fear of boredom.

(more Books on p 184)

* Associate Editor MATERIALS IN DESIGN ENGINEERING.

TECHNICAL LITERATURE

Russian-English Metals & Machines Dictionary. *Technical Dictionaries Co., New York. 1960. Paper, 8½ by 3 in., 112 pp. Price $9*

Contains 9000 Russian entries covering metallurgy, metals and alloys, metalworking and machines.

Standards for Wrought Aluminum Mill Products: 3rd Revision. *Aluminum Assn., New York. 1960. 8½ by 11 in., 96 pp.*

Presents data on mechanical, physical and other properties, standard tolerances and other useful information on standard aluminum alloys and mill products normally produced in these alloys. Information is also given on heat treatment, storage and inspection of aluminum products.

Thermoelectricity. *Edited by P. H. Egli. John Wiley & Sons, Inc., New York. 1960. Cloth, 6 by 9 in., 517 pp. Price $10*

The book is divided into four sections. The first section presents an introduction and a broad survey of the fundamental concepts of thermoelectricity. The second section examines the physics of the properties that determine thermoelectric performance. The third section emphasizes high temperature problems and explores the relative merits of static and transient methods of measuring thermal conductivity. The last section, written by the author, offers valuable guides for the selection of thermoelectric materials at this early stage of development.

Polystyrene. *W. C. Teach and G. C. Kiessling. Reinhold Publishing Corp., New York. 1960. Cloth, 5 by 7 in., 187 pp. Price $5*

Provides information on the chemistry, properties and manufacture of polystyrene. The authors include the latest information on the uses of polystyrene in appliances, electronics, packaging, housewares, toys and novelties, transportation, and furniture. One chapter is devoted to the manufacture, fabrication and use of expandable polystyrene.

Design of Steel Structures. *B. Bresler and T. Y. Lin. John Wiley & Sons, Inc., New York. 1960. Cloth, 6 by 9 in., 722 pp. Price $9.75*

Emphasizes the rational approach to the design of steel structures based on the understanding of both the elastic and plastic behavior of members and connections. Structural design codes are discussed in the light of rational analysis, empirical evidence, and practical requirements.

The authors have included excerpts from design calculations of several existing buildings and bridges to illustrate practical solutions of design problems.

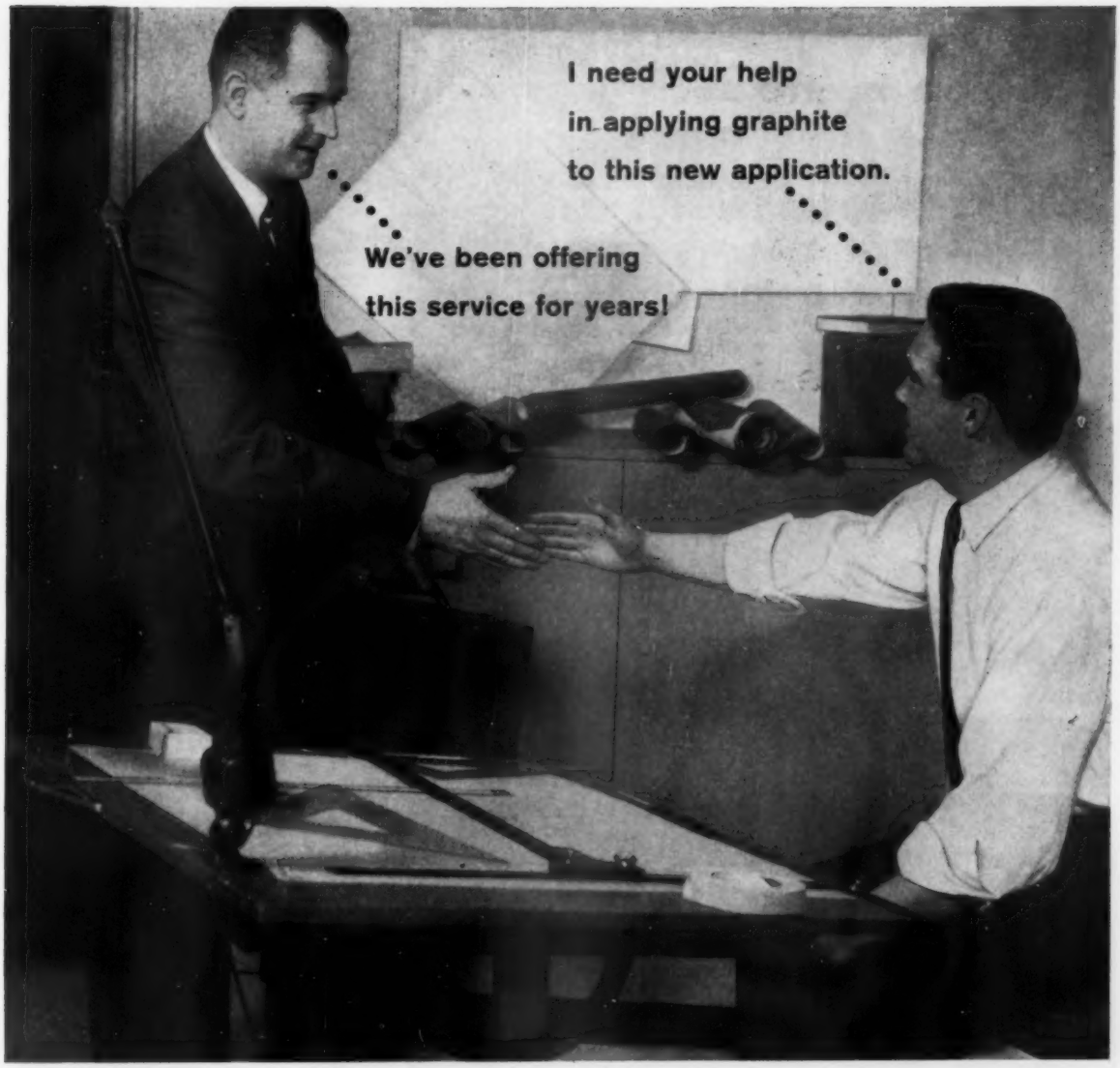
Reports

Standard for plywood COMMERCIAL STANDARD TS-5491 FOR DOUGLAS FIR PLYWOOD. *H. A. Bonnet, Commodity Standards Div., Dept. of Commerce, Washington 25, D. C.*

Requirements, tests, sizes, tolerances, nomenclature and definition of terms relating to various grades of Douglas fir plywood.

Cermets. CERMETS OF ALUMINA AND IRON OR IRON ALLOYS. *W. Jellinghaus and T. Shuin. Available from Henry Brutcher, Technical Translations, P. O. Box 157, Altadena, Calif. Price $18.40 (No. 4800)*

Report on latest German attempt at de-



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TECHNICAL LITERATURE

veloping commercially useful cermets based on iron and alumina. Discusses importance of particle size of powder mixes on performance of finished product. Gives properties of low oxide and high oxide iron-alumina cermets.

Cooling media STUDY OF EQUIPMENT COOLING SYSTEMS. *F. E. Schroeder, E. E. Towe, P. H. Lake and R. L Wunderman, Boeing Airplane Co. Nov '59. 178 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 161484)*

Study of cooling systems for electronic equipment used in vehicles operating at velocities of Mach 8 to 20 at altitudes from 80,000 to 200,000 ft. Comparisons are presented for expendable heat sink materials, pressurization gases, heat transport fluids, and several simplified cooling systems.

Ultrasonic welding FUNDAMENTALS OF ULTRASONIC WELDING (PHASE 1). *J. B. Jones et al, Aeroprojects Inc. May '59. 99 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.50 (PB 161677)*

Describes special instrumentation and techniques for observing and interpreting internal cyclic stresses, transient temperatures, and net energy in producing ultrasonic welded joints.

Radiation resistant diode RESEARCH IN RADIATION DAMAGE IN SEMICONDUCTORS. *J. W. Harrity and others, General Dynamics Corp. Feb '60. 157 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 161673)*

Describes a radiation resistant diode made of p-type germanium. Principal object of the study was to determine the mechanisms by which radiation degrades semiconductor devices.

Properties of rubber HIGH TEMPERATURE PROPERTIES OF ELASTOMER VULCANIZATES. *E. W. Bergstrom, Rock Island Arsenal. Jan '60. 45 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.25 (PB 161689)*

Discusses high temperature properties of vinylidene fluoride, methyl silicone, nitrile silicone, chlorosulfonated polyethylene, butadiene-styrene, polychloroprene and polyurethane rubbers. Methyl silicone, vinyl silicone and high strength silicone rubbers had excellent retention of physical properties both after aging and when measured at high temperatures. The vinylidene fluoride rubber had superior aging properties, but extremely poor retention of physical properties when measured at high temperatures.

Welding aluminum RECOMMENDED PRACTICES FOR GAS SHIELDED-ARC WELDING OF ALUMINUM AND ALUMINUM ALLOY PIPE. *1960. 40 pp. Available from American Welding Society, 33 W. 39th St., New York 18, N. Y. Price $2*

Covers, in a condensed form, all phases of aluminum pipe welding, from processes and machine settings, to welding techniques and heat treatment.

Molybdenum metal MOLYBDENUM METAL. *1960. 110 pp. Available upon request from Climax Molybdenum Co., Div. of American Metal Climax, Inc., 1270 Avenue of the Americas, New York 20, N. Y.*

Comprehensive information on the properties, production and fabrication of unalloyed molybdenum metal. The report places special emphasis on new advances in arc casting and powder metallurgy which have made it possible to produce ingots measuring up to 12 in. in dia.

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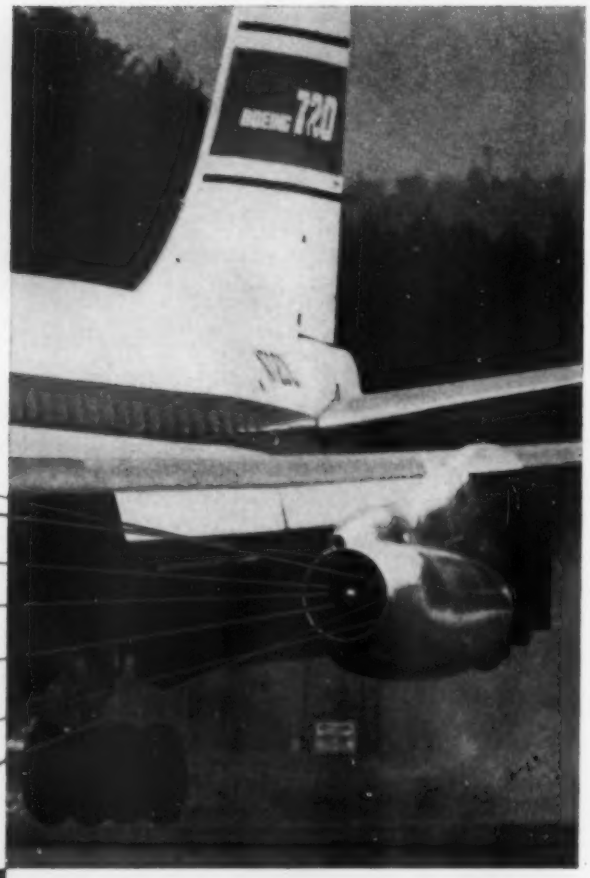

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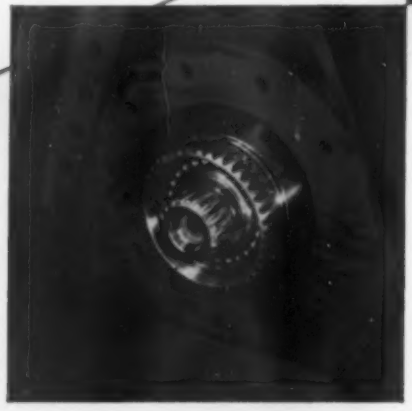

Thrust reverser bearing assemblies, made of Latrobe's Vac-Arc BG 41 Stainless, take compressive stresses of more than 600,000 psi and temperatures in excess of 800°F. as new Boeing 720 jetliner brakes to a stop. Bearings by Torrington Co.; Thrust Reversers by Rohr Aircraft; Jet Engines by Pratt & Whitney Aircraft.

VAC-ARC BG 41 "hot hardness" withstands critical braking action of new Boeing 720

Through the use of thrust reversers and wheel brakes, the new Boeing 720 has been brought to a full stop within 2200 feet after runway touchdown—bringing high speed jet service to restricted runway facilities throughout the world.

The thrust reverser bearing assemblies, made of Latrobe's new Vac-Arc BG 41 Stainless (modified Type 440 C), withstand the critical stresses at elevated temperatures imposed by the braking action of reversing the jet engine thrust.

Here's another example of Latrobe Metalmasters meeting the challenge for super steels in the jet and missile age. Vac-Arc Steels (consumable electrode vacuum melted) continue to set new standards for cleanliness, homogeneity and high strength.

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CHEMI-VIC puts you on the right track against ozone attack!

The basic feature of new CHEMI-VIC is well described in the photograph above. That's CHEMI-VIC on the left, compared to a similar, currently popular elastomer, after 144 hours in an ozone box (100 pphm) at 100°F.

CHEMI-VIC is brand new—a vinyl reinforced nitrile elastomer. In addition to outstanding resistance to ozone and weather, it offers high physical properties plus exceptional resistance to oil. Moreover, it's easy to compound and process on standard equipment.

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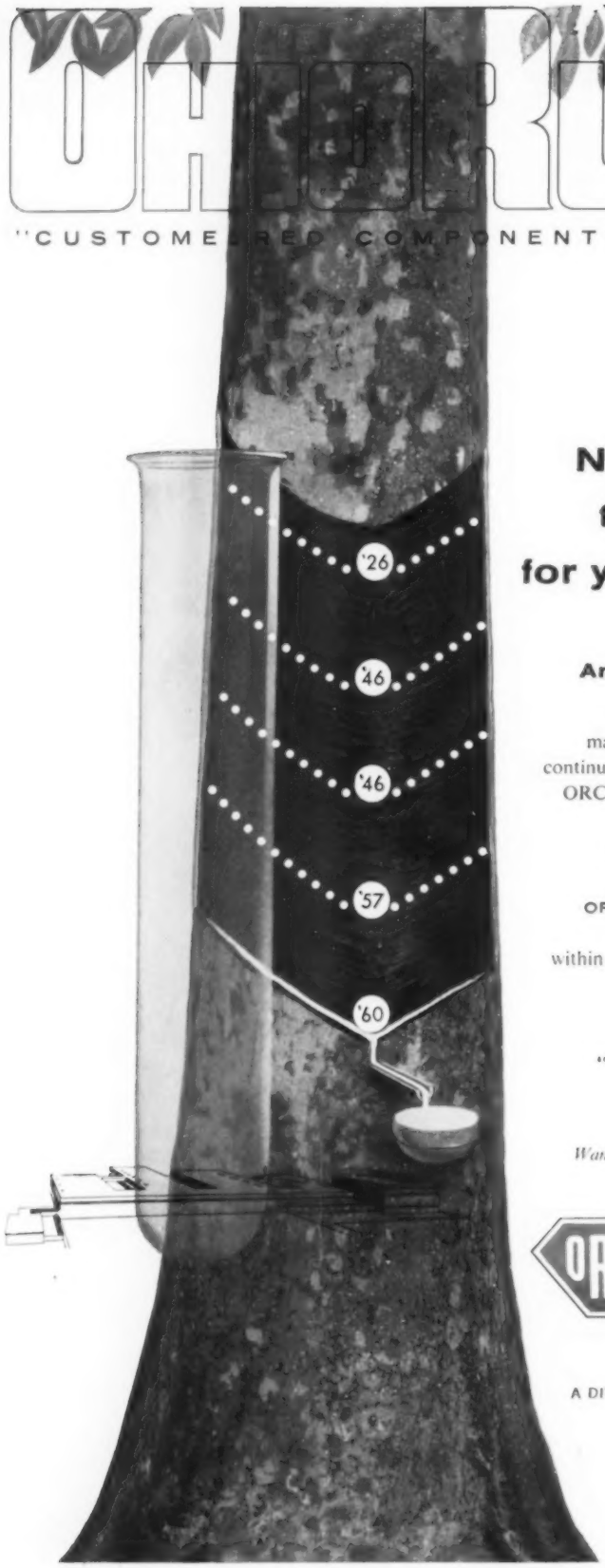

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And you made it possible!

Ohio Rubber's history of plant growth and manufacturing expansion dates back to 1926—continues through 1946 and 1957. And, in late 1960, ORCO opens its new Fort Smith, Arkansas plant—dedicated, as with the others, to serve you better—to supply your increasing needs for custom components.

ORCO SUM TOTAL: 5 major, geographically strategic plants . . . 1,200,000 square feet within 143 acres . . . over 2000 trained employees . . . diverse products of natural and synthetic rubber, neoprene, polyurethane, flexible and rigid vinyl . . . "customer-friends" like you across the board in industry, nationwide.

Want to know more about Ohio Rubber? Write today for our "Customeering" bulletin.

MP-200

ORCO THE OHIO RUBBER COMPANY

General Office • *Willoughby, Ohio* • WHitehall 2-0500

A DIVISION OF THE EAGLE-PICHER COMPANY

For more information, turn to Reader Service card, circle No. 424

(cont'd from p 18)

What's new IN MATERIALS

coloring matter.

Since most plastics are attacked by paint solvents, present coating formulations are specially formulated to be compatible with the base material. The coatings are easy to handle and can be applied the same way as any ordinary paint. In general, no special pretreatment is required before application. However, in the case of polyethylene a heat treatment is recommended before application to promote adhesion.

Cost of the coatings ranges from $7.95 to $8.95 per gal, but unit cost per part is quite low because coatings are thin and must only be applied in areas needing protection.

For more information, circle No. 605

New Russian Man-Made Fibers

How do man-made fiber developments in the Soviet orbit compare with developments in the West?

R. C. Laible and L. I. Weiner of the Quartermaster Research and Engineering Command, Natick, Mass. say "The ability of the Soviet orbit to produce man-made fibers and textiles in quantity is far behind that of the United States. However, Russia has produced at least three new fibers that have no counterparts in the Western world."

They are: 1) Enant, a nylon 7; 2) Ftorlon, a fluorine-containing copolymer; and 3) Vinitron, a combination of nitrocellulose and chlorinated polyvinyl chloride.

Characteristics of fibers

Enant—Laible and Weiner say glowing claims have been made in Russian journals about the high temperature stress-strain properties and ultraviolet ray resistance of Enant. The Russian journals usually compare the material to nylon 6, but tests at the Quartermaster laboratories show it is chemically closer to nylon 7.

Other tests show the material has a melting point of 435 F, which is slightly higher than nylon 6 (420 F) but lower than nylon 66 (480 F). Enant yarn contains 12 single, uniformly shaped filaments 22μ in dia.

Ftorlon—Although many Russian, German and American journals refer to Ftorlon, none gives any clue as to its identity other than to call it a fluorine copolymer.

Comparative tests between Ftorlon and TFE show Ftorlon is soluble in selected solvents, hence spins more easily than TFE. Microscopic observations show the material shrinks at 300 F and decomposes at temperatures between 445 and 510 F; this indicates that the heat stability of Ftorlon is far below that of TFE which has an apparent melting point of 620 F. But the stress-strain properties of Ftorlon are said to be better than those of TFE.

It is possible that Ftorlon is chemically closer to Kel-F (polytrifluorochloroethylene) or polyvinyl fluoride than to TFE. Comparisons were made with TFE since it is the only fluorine-containing polymer available in fiber form in this country.

Ftorlon yarn contains over 200 single, irregularly-shaped filaments 3 to 5μ in dia.

Vinitron—Tests at the Quartermaster laboratories show Vinitron does not shrink in water, and has a softening point of 300 F.

Soviet threat: fibers with super properties

A possible threat from Soviet textile research lies not in the development of slightly improved counterparts of nylon, Orlon, etc., but in the possibility of a real breakthrough emanating from extensive work in the field of new and unusual poly-

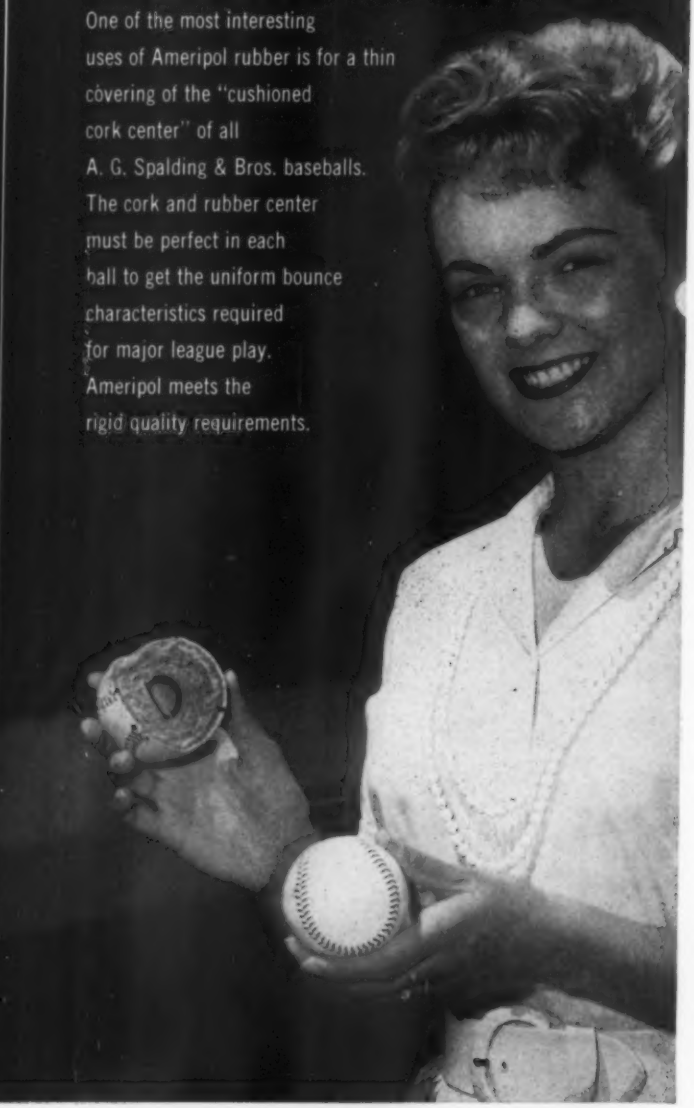
(continued on p 194)

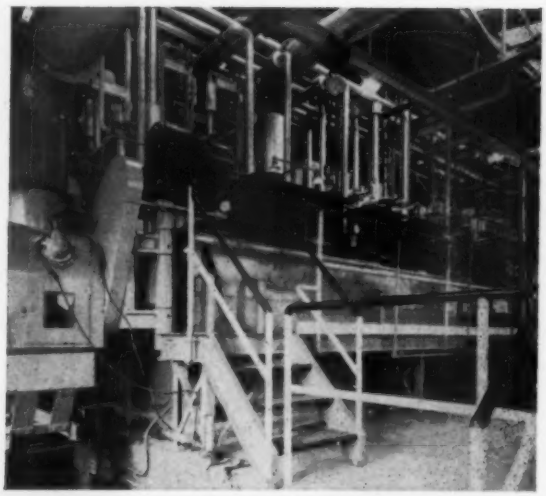
Based on an article appearing in the Apr '60 issue of *Textile Research Journal*, published by Textile Research Inst., Princeton, N. J.

NEWS FROM GOODRICH-GULF

AMERIPOL FOR THE LONG BALL

One of the most interesting uses of Ameripol rubber is for a thin covering of the "cushioned cork center" of all A. G. Spalding & Bros. baseballs. The cork and rubber center must be perfect in each ball to get the uniform bounce characteristics required for major league play. Ameripol meets the rigid quality requirements.





HUGE MACHINE SETS FAST PACE IN SYNTHETIC RUBBER DRYING

This 40-foot long machine, at the Institute, West Virginia plant of Goodrich-Gulf, is the largest production-scale extrusion dryer in the industry. The machine drastically cuts drying time, also delivers a polymer free of moisture and with low ash content to improve product quality.

The extrusion dryer has a design capacity of 6000 to 8000 pounds per hour. Entire cycle time, from the time wet rubber enters the feed box until it passes through a pelletizing die, is 5 to 10 minutes. Development of this machine represents a major forward step in production of synthetic rubber.

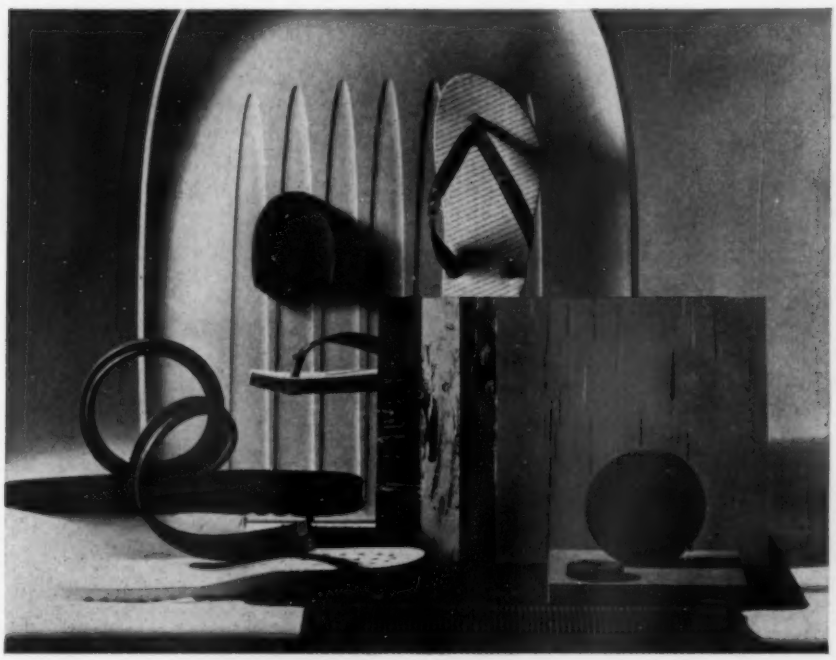
NEW AMERIPOL POLYMER EASIER TO PROCESS ...IMPROVES PRODUCT QUALITY

Ameripol 4601 is a new polymer designed with medium-low viscosity to enable the fabricator to reduce processing time and power costs, and to eliminate the need for costly peptizing agents. Physical properties compare favorably with those of a peptized high-viscosity polymer such as SBR 1502.

This polymer permits easier mixing, smoother calendering, faster extrusion. The polymer exhibits less shrinkage and improved smoothness and quality. The elimination of peptizing agents not only reduces cost, but avoids a possible source of discoloring.

For many types of rubber products including sponge, floor tile, soling and heels, mats, and extrusions, you can switch to Ameripol 4601 and obtain equal or improved physical properties, while reducing processing costs.

This new polymer is another result of Goodrich-Gulf's continuing product development program which can help you in fabrication or use of synthetic rubber polymers. Polymer evaluations and test data are available through Goodrich-Gulf Technical Service. Address: 1717 East Ninth Street, Cleveland 14, Ohio.



AMERIPOL 4601
has ideal
qualities for many
products

- Light Color
- Low Viscosity
- Good Physical Properties
- Low Water Absorption

Ameripol
THE PREFERRED RUBBER

Goodrich-Gulf Chemicals, Inc.
THE ONE TO WATCH FOR NEW DEVELOPMENTS

For more information, turn to Reader Service card, circle No. 384

mers, say Laible and Weiner.

It is very possible, they say, that Russian work on organometallic and inorganic polymers will eventually lead to the development of fibers with an entirely new order of magnitude of heat resistance, chemical resistance and impact properties.

According to the two men, the country that successfully develops fabrics of this type with the required mechanical and thermal properties could gain an advantage in such military end items as parachutes for supersonic aircraft and missile use, personnel armor and thermal protective clothing.

More Uniform Heat Treatments

Better heat treated steels are promised with the development of a new salt bath furnace that uses an entirely new concept in salt bath heating.

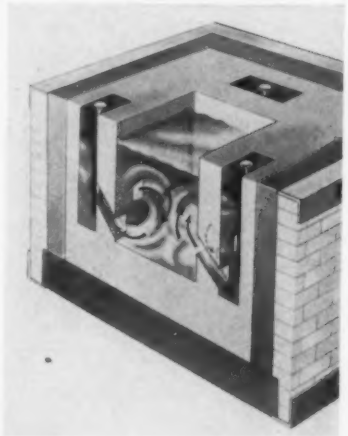
A big advantage of the furnace is that it maintains a constant temperature over its entire working area. Thus steels treated in the furnace are assured an even heat treatment.

How it operates

The furnace, developed by Upton Electric Furnace Co., Roseville, Mich., is heated by passing electrical currents through a series of tunnels in the walls of the furnace. The walls separate the main portion of the salt bath from adjacent small wells where current is introduced by electrodes.

Convection currents set up by the flow of electricity causes salt to move through the series of tunnels from the main salt bath to the electrode well and from the electrode well back to the main salt bath (see accompanying photo diagram). Because of the rapid circulation, temperature of the salt is only a few degrees higher in the tunnels than in the main salt bath.

The developer says the furnace can heat 1200 lb of steel each hour from room temperature to 1600 F and 800 lb each hour from room temperature to 2300 F.



***Cut-away view** shows operating principle of new salt bath furnace. Convection currents set up by the flow of electricity cause salt to move through a series of tunnels from the main salt bath to the electrode well and from the electrode well back to the main salt bath.*

Sales and service for Upton's new furnace are handled by Lindberg Engineering Co., 2456 W. Hubbard St., Chicago. KEY NO. 611

Easy-Processing SBR Rubber

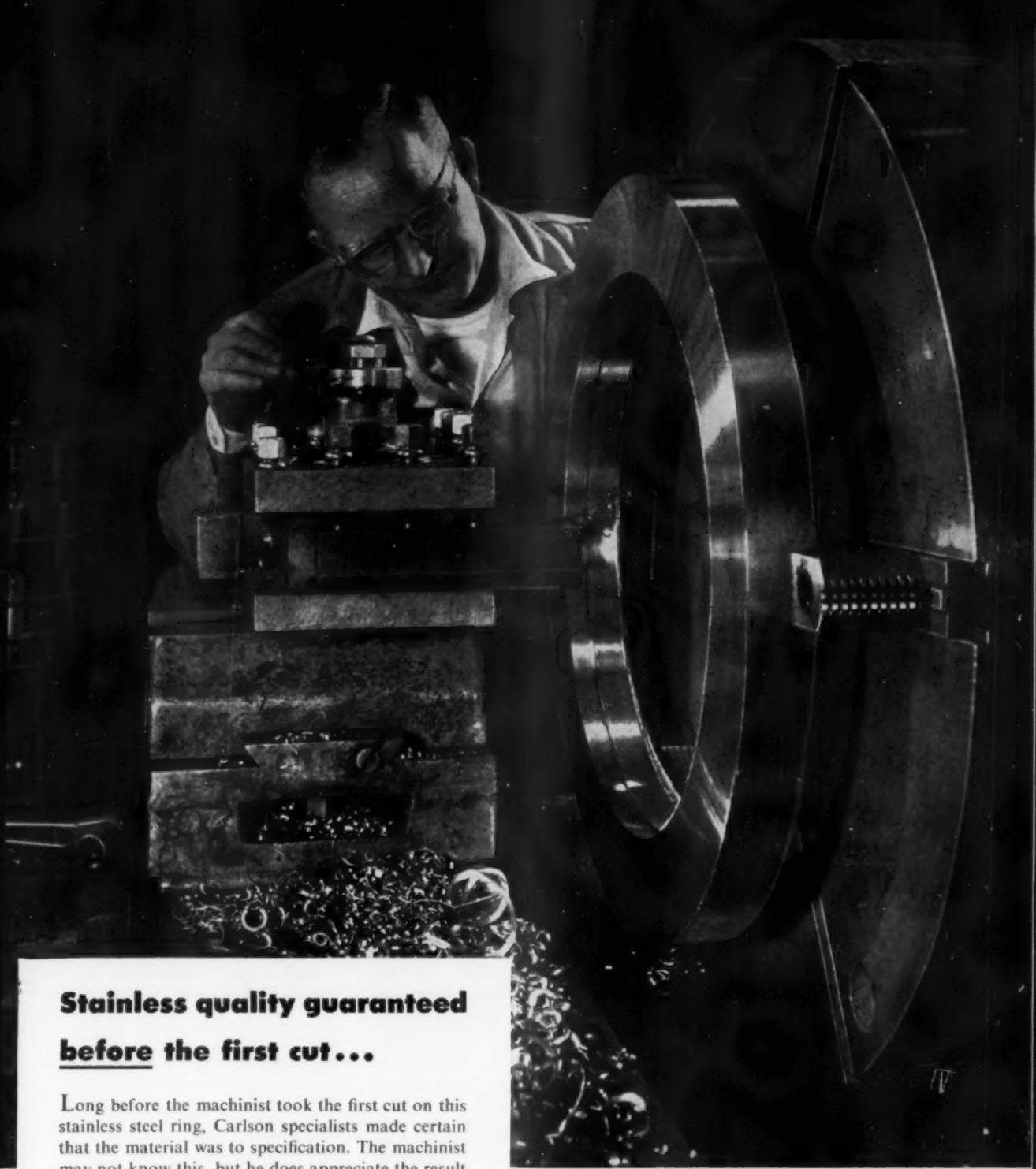
A new type of styrene-butadiene rubber is said to have a 32% improvement in processability (as measured by a special quality control test) over conventional SBR rubbers.

The material, called Plioflex 1778 and developed by Goodyear Tire & Rubber Co., Akron 16, Ohio, is a light colored, oil-extended, general purpose rubber designed for use in light and dark colored end products.

H. R. Thies, general manager of the company's Chemical Div., says the new product retains all of the desirable properties of styrene-butadiene rubber. According to Thies, all production runs of SBR rubber at Goodyear's Houston, Tex. plant have been converted to the new, improved version.

How test works

In the special quality control test, processability of rubber is deter-



Stainless quality guaranteed

before the first cut...

Long before the machinist took the first cut on this stainless steel ring, Carlson specialists made certain that the material was to specification. The machinist may not know this, but he does appreciate the result —the ease of machining to meet the most exacting requirements.

Whether you want rectangular stainless plates, pattern-cut special shapes, or machined products, you will save fabricating time by making full use of Carlson services. Fabricators of chemical, process, nuclear, aircraft and missile equipment recognize the advantages of these services.

Our specialists will be glad to work with you in producing just what you want, delivered on time. Telephone, write or wire for action.

G.O.CARLSON *Inc.*

Producers of Stainless Steel

126 Marshallton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

Plates • Plate Products • Heads • Rings • Circles • Flanges • Forgings • Bars and Sheets (No. 1 Finish)

For more information, turn to Reader Service card, circle No. 348

What's new IN MATERIALS

mined by measuring the power consumption curve of a Banbury mixer as it mixes samples from production batches of rubber. The time taken to reach the height of the power consumption curve, after an initial surge of power, is in direct relation to the rubber's processability characteristics. Rubber which fails to reach the power consumption height within prescribed time limits will not process satisfactorily.

In addition to predicting rubber processability, the test can be used as a reliable measure of the effects of premastication on rubber compounds. **KEY NO. 612**

Colored Titanium Metal

Brilliantly colored titanium is being produced by a new process in which the metal is colored without the use of harmful dyes or paints. Details as to how the process works have not been revealed.

The method, developed by Hi-Shear Rivet Corp., 2600 W. 247th St., Torrance, Calif., is said to impart a single or multi-colored surface to titanium that is corrosion resistant, decorative and resistant to temperatures up to 600 F.

Potential applications

The process can be used to color code titanium fasteners, valves, nuclear reactor parts, and chemical pipe and fittings. The company says the colored coating, when applied to titanium nuts and bolts, alleviates galling conditions normally encountered in thread combinations.

The coloring process can also be used to make commercial titanium products eye appealing. For example, colored marine hardware made of titanium is decorative and does not pit, rust or require polishing after exposure to salt air. In addition, the process can be used to produce an electrically conductive or nonconductive coating.

Properties

Tests show that colored titanium is inert to all alkalis and to most acids. The coating is color fast after six months' outdoor weathering, after 100 hr salt spray testing, and after exposure to nuclear radiation.

The coloring process is applicable to all titanium alloys and does not alter the physical or mechanical properties of the base metal, according to the developer. **KEY NO. 613**

Five New Brazing Alloys

Five new and improved brazing alloys have been placed on the market in recent months. All are claimed to speed up the joining and fabrication of ferrous and nonferrous metal parts. Three are silver alloys and two are bronze.

1. Silver alloys

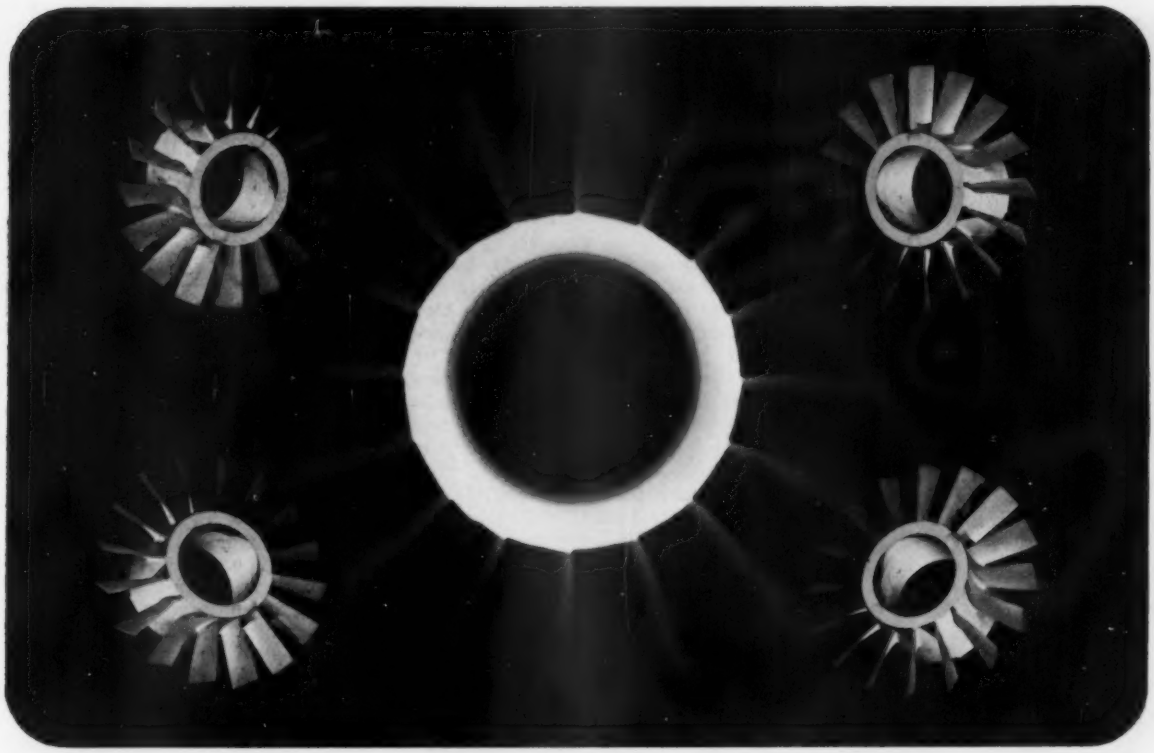
EutecSil 1020FC is the name of a flux-coated silver brazing alloy that is said to permit joining of metal parts at a speed three times faster than with conventional silver brazing alloys. The new alloy is available from Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N. Y. It is supplied in rods measuring 1/16 and 3/32 in. in dia.

The developer says that because of its ease of application and because it automatically provides premeasured flux control, EutecSil 1020FC alloy requires a minimum of precleaning and preheating. The brazing alloy eliminates the need for a separate flux which has to be mixed, applied and dried separately before application of a brazing rod.

The brazing material is expected to find use in the fabrication and repair of electronic waveguides, automobile radiators, heat exchangers for refrigerators and air conditioners, instrument tubing and copper floats. The developer says that deposits are cadmium-free and thus the product can be used safely on food vessels and processing equipment. **KEY NO. 614**

Silvaloy 15 and Silvaloy 5 are the names given by American Platinum & Silver Div., Engelhard Industries, Inc., 75 Austin St., Newark 2, N.J.

WATCH FOR 'SELECTOR' — M/DE's *Materials Selector Issue*—revised, expanded and updated—will be published later this month.



Pinwheels for an Inferno

Turbine wheels in today's jet engines face intense heat and ultra-precise operating requirements. Austenal's Microcast Division checks them for soundness with radiography using Kodak Industrial X-ray Film, Type AA

Whirling at fantastic speeds at white heat is no sissy job. It takes castings molded to utmost accuracy to stand up dependably in a powerful jet.

Austenal Company, Microcast Products, casts such intricate parts as these by the "lost wax" method—and to check, lest any flaw lies hidden within, the castings are radiographed on Kodak Industrial X-ray Film, Type AA.

This is the way to be sure only high-quality work reaches the customer. It is a way good reputations are built and new business won.

Wouldn't you like to know how radiography can work for you? Talk it over with an x-ray dealer or write us for a Kodak Technical Representative to call.

Read what Kodak Industrial X-ray Film, Type AA, does for you:

- Speeds up radiographic examinations.
- Gives increased detail visibility and easy readability at all energy ranges because of high film contrast.
- Provides excellent uniformity.
- Reduces the possibility of pressure desensitization under shop conditions.

EASTMAN KODAK COMPANY
X-ray Division Rochester 4, N. Y.

Kodak
TRADE MARK

For more information, turn to Reader Service card, circle No. 367

No. 19 of a series

Eastman 910 Adhesive solves another production bottleneck

Templet Industries, Inc., Brooklyn, N. Y., produce steel-rule stamping dies that can cut through 1-inch steel plate.

Neoprene ejector springs, conforming to the shape of the die, are mounted alongside the steel rules on the base plates. Bringing the dies together compresses the neoprene. When the dies are released, the neoprene expands to its original thickness, ejecting the stamped part and the scrap.

Needed was a simple method of securely bonding the neoprene to the metal and wooden base plates. The answer? Fast-setting, high-strength Eastman 910 Adhesive. The bond it makes holds for the life of the dies, which can run to more than 250,000 stampings.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials strong bonds are made within minutes.

What production or design problems can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9111 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-11, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

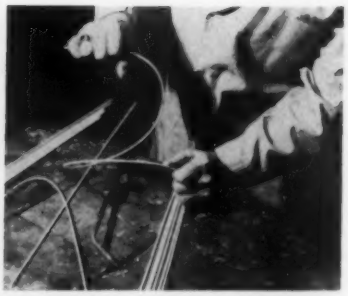
For more information, circle No. 365

What's new IN MATERIALS

to its two improved silver brazing alloys.

Although paste fluxes may be used with the alloys, the producer says their self-fluxing ability makes them particularly useful in silver brazing of joints where complete flux removal is both difficult and important, as in electrical and refrigeration equipment. According to the developer, brighter, cleaner and more consistent finishes on the two alloys eliminate foreign matter and contaminants from brazed joints.

The improved Silvaloy 15 brazing alloy is designed for use on copper and copper alloys, silver, tungsten and molybdenum. It is not recommended for use on ferrous alloys or nickel. The improved Silvaloy 5 alloy, which has properties similar to those of Silvaloy 15, is designed as a more economical alloy for use on electrical and refrigeration equipment. **KEY NO. 615**



***Bronze brazing rods** are coated with a special flux that does not crack when the rod is bent double.*

2. Bronze alloys

Two flux-coated bronze brazing alloys are available in rod form from All-State Welding Alloys Co., Inc., 249-55 Ferris Ave., White Plains, N. Y. The producer says the rods are coated with a special, nonfuming, noncharring flux that does not crack when the rod is bent double. One alloy is coated with a thin layer of flux and is designed for use on high speed production lines. The other alloy is coated with a thicker layer of flux and is designed for maintenance use. Both rods are supplied in sizes from 3/32 to 1/8 in. in dia. **KEY NO. 616**

Ceramic Films for Electronics

Experimental nitride, silicide and oxide evaporated films show promise of furthering recent advancements made in the electronics industry with evaporated films of metals and metal alloys.

The newer film materials are generally harder and more refractory than metal alloys, and selected combinations of these materials offer a greater range of properties than are possible with metal and metal alloy evaporated films.

These are the claims made by Edwin H. Layer of Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, who recently completed a study on a group of ceramic materials that appear suitable for film-type electronic devices.

Nitride films—Mr. Layer first studied a number of transition metal nitrides, and the best of these was a chromium-titanium-nitride film.

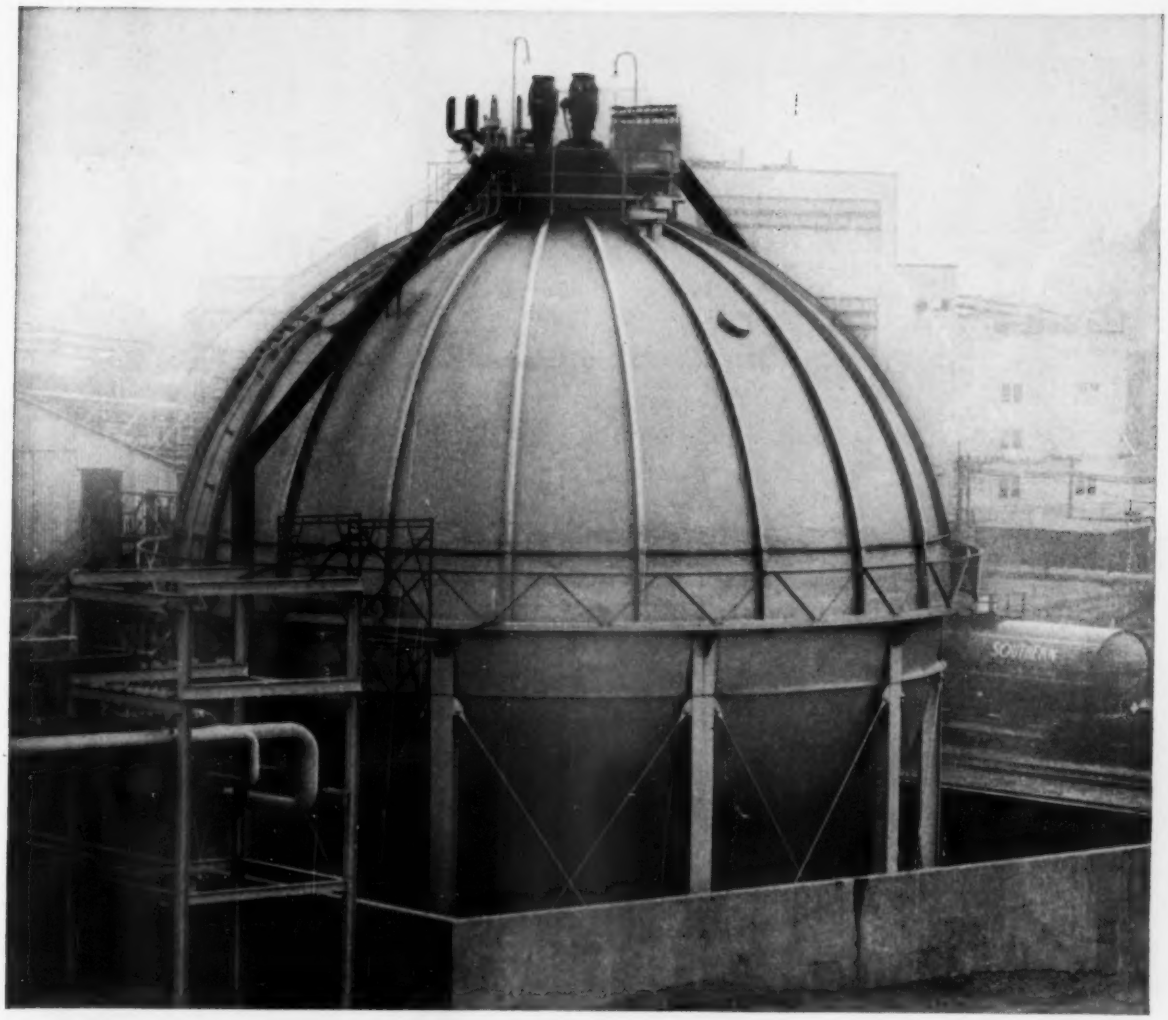
The film has a slate gray color, and is hard, abrasion resistant and stable at high temperatures. It is very adherent to unglazed ceramics, and can be made adherent to glass-like substrates. The film shows promise for use in resistors and potentiometer elements.

Silicide films—An evaluation of film-type silicides shows that they are more stable than nitride films in oxidizing atmospheres, and do not change appreciably in electrical resistance when exposed to air at high temperatures. Best film of this group was a chromium-silicon film deposited by a flash-evaporation technique. The method consists of dropping powders of the alloy onto a preheated tungsten strip.

Experimental chromium-silicon films that proved most interesting from an electronic standpoint were those deposited from a chromium-silicon alloy containing 24% chromium and 76% silicon by weight.

Tests by Layer show that chromium-silicon films remain stable after aging 1000 hr at temperatures up to 480 F.

Oxide films—The best oxide film evaluated by the Battelle researcher was an indium oxide film. From electrical and optical standpoints, an indium oxide film has the good light transmittance and low electrical resistance exhibited by very thin metal films. And it is rugged and



2¼% nickel steel tank stores 2000 tons of liquefied chlorine at −30°F... safely

20-year service record in many installations proves this nickel steel dependable for storage of liquefied gases down to −75°F.

In two decades of service in the recommended temperature range, there has never been a single incident of field failure of any 2¼% nickel steel vessel.

This record alone would be proof enough. But here's more:

- The *only* material approved for ocean shipment of liquefied propane is 2¼% nickel steel. Temperature: −44°F.
- This steel conforms to ASTM Specifications A203 (Grade B) and A300. It readily exceeds the minimum specified impact requirement of 15 ft-lb. keyhole Charpy at −75°F.
- The standard welding and forming operations are performed on 2¼% nickel steel without difficulty.
- The ASME Boiler and Pressure Vessel Code allows design stresses to 17,000 psi using 2¼% nickel steel.

Knowing these facts, it's easy to see why Columbia-Southern approved this material for this 2000-ton-capacity sphere. It bulk-stores chlorine at −30°F and at atmospheric pressure. Now in service 4 years, the tank fulfills every expectation of the fabricator, and of Columbia-Southern Chemical as well.

If you'd like complete data on 2¼% nickel steel, and other nickel alloy steels for service at temperatures as low as −320°F, write for your copy of "Properties of Nickel Steel Plates at Low Temperatures." Just drop a postcard to:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

For more information, turn to Reader Service card, circle No. 396

less likely to be rubbed off if accidentally abraded.

Mr. Layer says an indium oxide film can be used as a transparent heater for various defog, defrost and de-ice applications in aircraft and automobiles. An even more promising use is as a transparent electrode for electroluminescent or light-amplifier applications. Layer says the application is possible because neither the substrate nor the film need be heated above 390 F in order to achieve satisfactory film properties. Hence it may be possible to apply an indium oxide film directly to a plastics-bonded electroluminor without destroying the base properties.

Fiberglass Roving

A fiberglass roving recently introduced by Sackner Products, Inc., 901 Ottawa, N. W., Grand Rapids 2, Mich. is made of random spun glass fibers that are said to retain greater flexibility than combed fibers used in conventional fiberglass roving.

The result, says the producer, is a plastics reinforcing material that drapes better, stretches better, cuts more easily, and generally forms better than conventional fiberglass roving in molding fiberglass boat hulls, furniture, jigs and fixtures, and other shapes. KEY NO. 617

Two-Part Adhesive Is Easy to Mix, Apply

A unique packaging design makes it easier to mix and apply a new two-part epoxy adhesive.

The package is a small saran tube that contains both the base material and the catalyst. The catalyst is contained in a smaller tube inside the larger tube. To mix, the small tube is broken by squeezing; the catalyst pops out of the smaller tube and is kneaded into the base. After the base and catalyst are mixed by repeated squeezing of the saran tube, the end is snipped off and the tube serves as the applicator.

The product was developed by Armstrong Cork Co., Industrial Div., Lancaster, Pa. The company is offering an experimental kit of the

Steel

for Strength
. . . Economy
. . . Versatility

Casting... or Forging?

From the look of it, most people would probably guess casting. But it's a forging. Which proves a point. Many parts *look* too complicated for forging, but actually aren't. By careful selection of parting line, close trimming, and punch-outs, we're often able to forge parts you'd never expect to obtain as forgings. If you have such a part (and would welcome the strength and economy of forgings), send us a finished print. We'll be glad to study it and tell you frankly whether or not we can forge it. If we can, you can count on us for fast delivery.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 342

For more information, turn to Reader Service card, circle No. 461

What's new IN MATERIALS

***Catalyst** in new, two-part adhesive system is contained in a small tube that has been placed inside a larger tube holding the base material. After mixing . . .*

***. . . end is snipped off** and the tube serves as an applicator.*

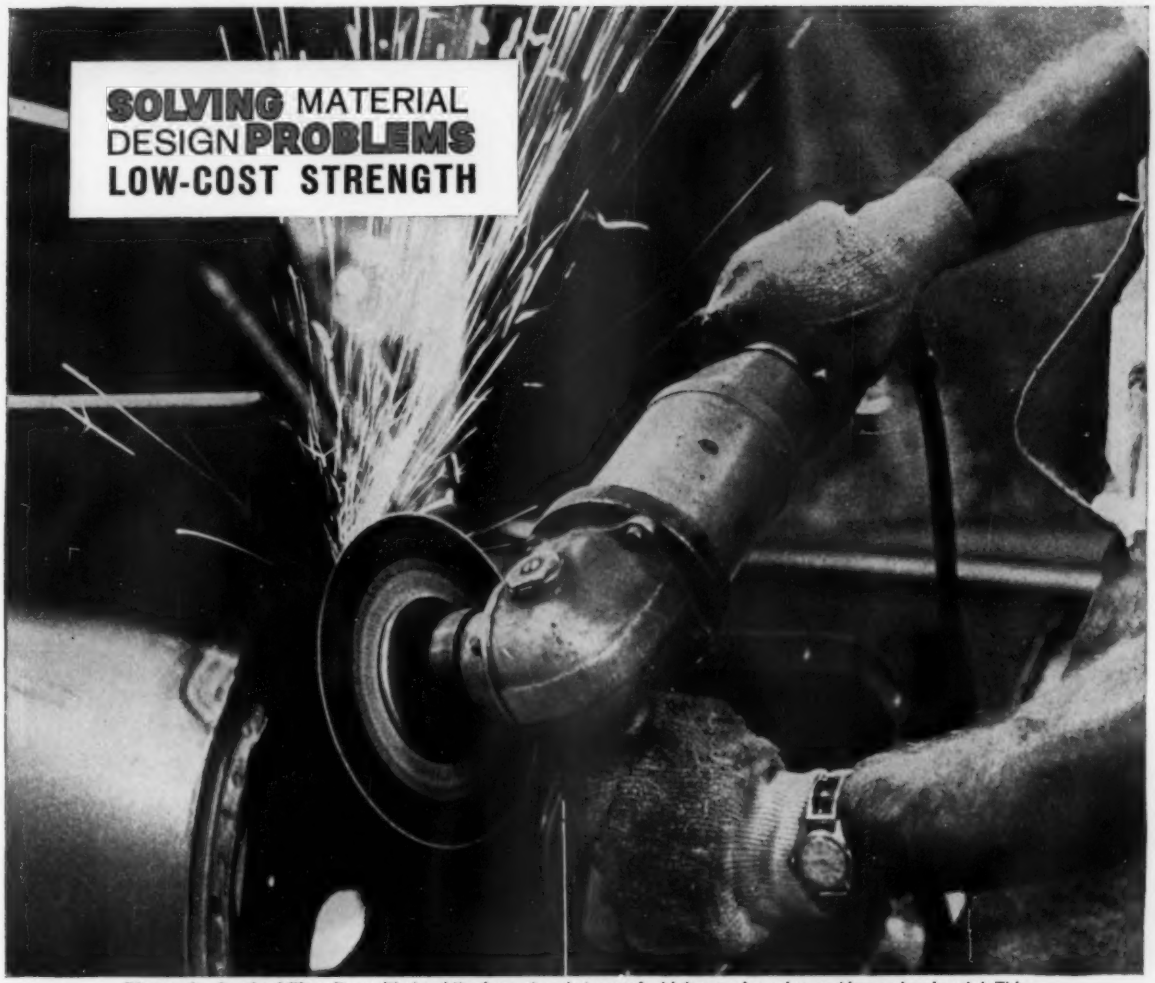
two-part adhesive packet for $3.

The adhesive, called J1158, is said to give a resilient bond over the temperature range —40 to 185 F.

The epoxy adhesive was developed originally for bonding mirror brackets to automobiles. However, it is expected to be used in one-shot bonding applications in the electronic, automotive, toy and aircraft industries. It can be used to bond metal to glass, metal to metal, plastics to glass, rubber to metal, and rubber to glass. KEY NO. 618

New Semiconductors

New inorganic semiconductors now on the market include 1) five new grades of gallium arsenide, and 2)

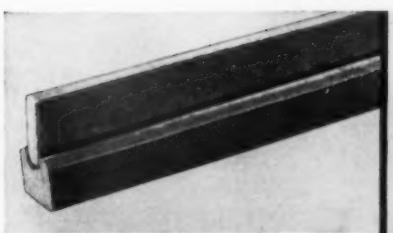


Diamond vulcanized fibre discs withstand the impact and stress of a high-speed sander working on hard metal. This tough and flexible material combines long life with very low cost in some of the most difficult jobs in industry.

Tough, light-weight and low cost, Diamond® vulcanized fibre is an electrical insulator that combines excellent mechanical properties with easy fabrication in low cost tools. It is available in standing forms or in parts manufactured to your specifications. Whatever other properties you're looking for — heat resistance, long wear, machinability or compressive strength — you can easily find in the industry's most complete line — CDF laminated plastics, vulcanized fibre and flexible insulating materials. Check our specs in Sweet's PD file or write on your letterhead for General Folder 60.

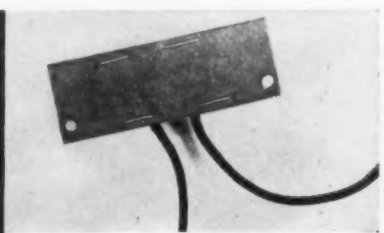
CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 25, DEL.
In Canada, 46 Hollinger Road, Toronto 16, Ont.



Low coefficient of friction combined with low cost make Diamond vulcanized fibre ideal for such uses as tracks for sliding glass doors and windows.

Superior electrical properties. A reason why CDF's Diamond vulcanized fibre is widely used for slot liners in small electric motors and transformers.



Low cost. Diamond vulcanized fibre helps keep electrical appliance costs low. This food mixer insulator is an example.

For more information, turn to Reader Service card, circle No. 353

germanium alloyed with indium-gallium.

1. Gallium arsenide

Ohio Semiconductors, Inc., 1205 Chesapeake Ave., Columbus 12, Ohio recently announced the availability of five new grades of gallium arsenide for use in semiconductor devices. Each grade is characterized as to carrier concentration, mobility and electrical resistivity. Four of the grades are dense materials; the fifth is a dense, fine-grained material. Prices range from $8 to $37.50 per gm, depending on grade.

KEY NO. 619

2. Germanium-indium-gallium

A new semiconductor material—germanium alloyed with indium-gallium—is being produced by Alpha Metals, Inc., 56 Water St., Jersey City 4, N. J. The material is supplied in spheres, foil, disks, rectangles, squares and washers.

KEY NO. 620

New Aluminum Alloy May Replace 6061-T6

A new aluminum alloy is expected ultimately to replace alloy 6061-T6 as a standard material for making fasteners and specialty screw machine parts.

Reason: it has better machining properties and higher yield strength, yet is priced the same.

The new alloy, called 6262-T9, is available in production-lot quantities from Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19. It is supplied in standard 12-ft lengths in round or hexagonal rod and bar.

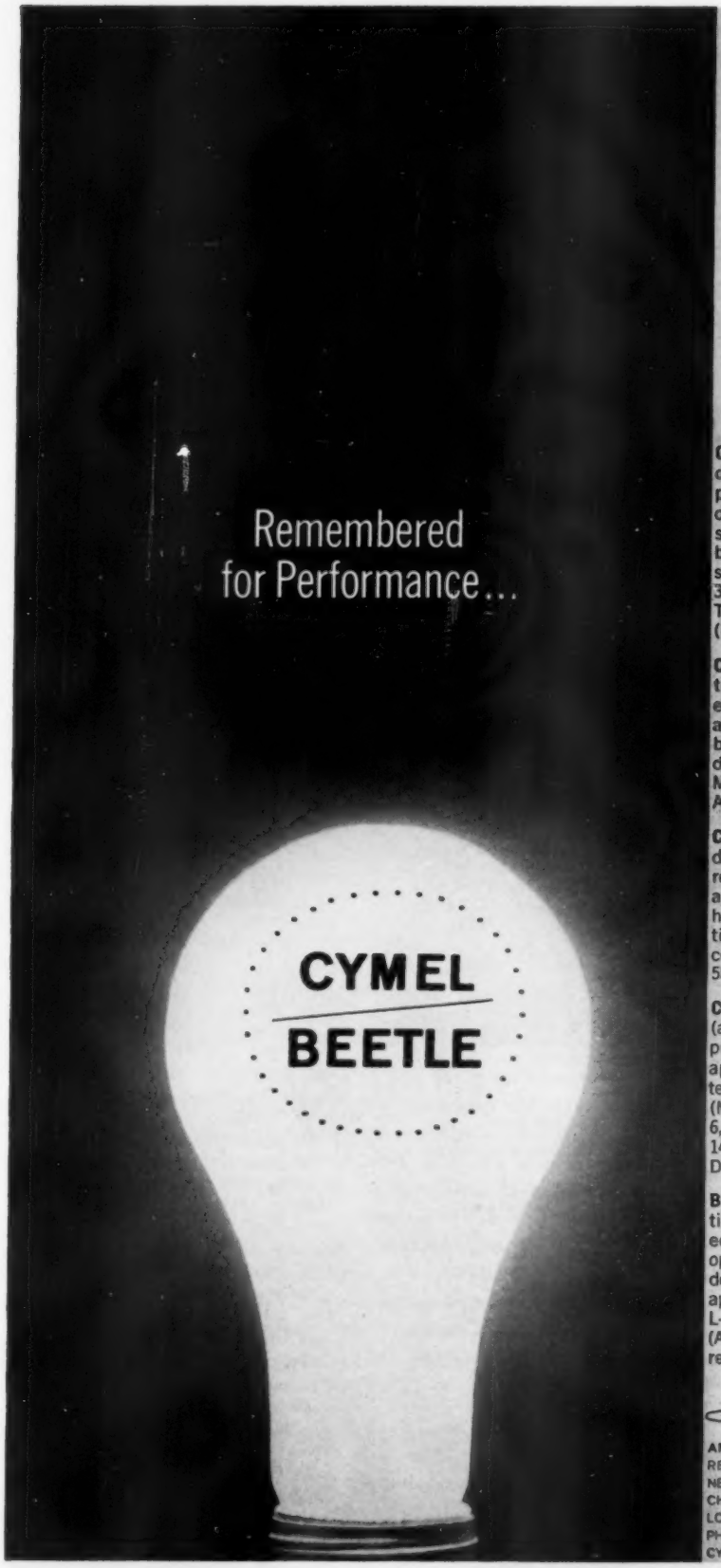
The alloy is a member of the aluminum - magnesium - silicon family, and contains lead and bismuth for increased machinability. It is expected to be used for fittings and couplings, and for screw machine parts in cameras and other products.

How alloy rates with other screw machine stock

Test data show that the new alloy machines better than the standard

PROPERTIES OF 6262-T9 ALLOY

Tensile Strength, psi	58,000
Yield Strength, psi	55,000
Elongation, %	10



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PLASTICS

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DEPENDABLE ELECTRIC PROPERTIES UNDER ADVERSE CONDITIONS
EXCELLENT ABRASION-RESISTANCE
CHEMICAL RESISTANCE

CYMEL 3135—3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SP1 SPEC NO. 27025.

CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E—Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SP1 SPEC NO. 30026.

CYMEL 1500 (wood flour-filled)—CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SP1 SPEC NO. 27026.

WRITE FOR COMPLETE TECHNICAL DATA.

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machine screw alloys 6061-T6, 2017 and 2024, but not as well as 2011-T3. Alloy 6262-T9 has a relative chip size rating of 1.4, compared to 1.0 for alloy 2011-T3. On the same scale, alloys 2017 and 2024 have a chip size rating between 2.0 and 3.0, and alloy 6061-T6 has a 4.0 rating.

The guaranteed minimum yield strength (48,000 psi) of the new alloy is higher than typical yield strengths for any of the four standard alloys. Its corrosion resistance and finishing characteristics are as good as those of alloy 6061-T6, and better than those of 2017, 2024 and 2011-T3. **KEY NO. 621**

Ceramic Powders for Plasma Arc Coating

Norton Co.'s Electro-Chemical Div., P. O. Box 87, Niagara Falls, Ont. says it is prepared to offer a wide range of boride, carbide, nitride and oxide powders for use in plasma arc spraying equipment.

Powders can be supplied in particle sizes ranging from –150 to 325 mesh. The producer says four other particle size ranges (not disclosed) are also available.

The following materials are sold in powder form for plasma arc spraying:

Borides—Chromium boride, dichromium boride, molybdenum boride, molybdenum diboride, titanium boride, vanadium boride and zirconium boride.

Carbides—Boron carbide (technical grade), boron carbide (high boron grade), chromium carbide, titanium carbide, zirconium carbide (technical grade), and zirconium carbide (high purity).

Nitrides—Titanium nitride.

Oxides—Alumina, diopside, mullite, spinel, stabilized zirconia, barium titanate, calcium zirconate and fused chromic oxide.

Plasma arc coatings

Coatings applied with a plasma arc torch are said to be quite different in appearance and character than those produced by other processes. Bonds of plasma arc coatings to the base material are generally chemical and mechanical in character and are much stronger than

That's a test pilot undergoing several "G's" in one of those human centrifuges. His life and the progress of future generations depend on the performance of many tubular parts built to rigid specifications, tight tolerances.

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A JOHNSON MATTHEY ASSOCIATE "METALS FOR PRECISION AND PERFORMANCE"

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bonds obtained by electroplating, vapor depositing or metal spraying.

(For more detailed information on plasma arc spraying, see M/DE, Mar '59, p 133, and Feb '60, p 180.)

KEY NO. 622

Bimetallic Pipe Sold in Wide Choice of Metals

A new technique is said to make possible the construction of bimetallic pipe in a wide choice of metals. The new fabricating method was developed by Gray Tool Co., P. O. Box 2291, Houston, Tex.

In Gray's process, a seamless lining is hydraulically expanded into the base pipe, forming the lining tightly against the inside of the base pipe material. Additional pressure expands the base pipe, and on return to normal operating pressure the lining is firmly held against the base pipe due to differential contraction.

Usually the base pipe is standard carbon steel in regular pipe sizes and schedules, and linings are monel, nickel or stainless steel.

The bimetallic pipe can be butt welded, flanged and bent without damage to the lining or to the bond between the lining and base pipe.

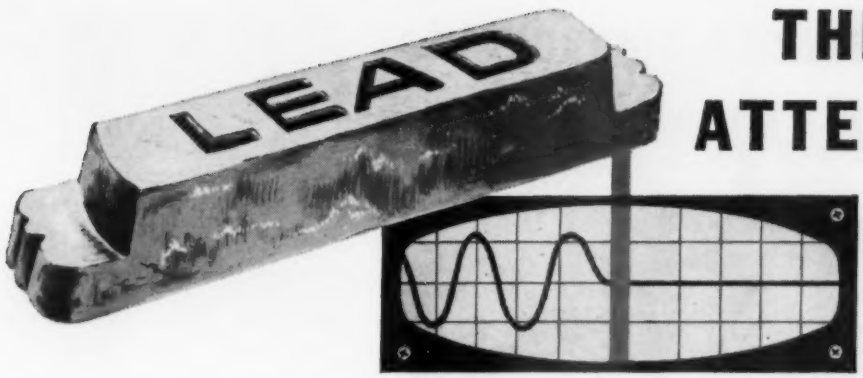
KEY NO. 623

New Polyesters Are Tough, Easy Handling

Five companies have recently developed new polyester resins that are designed for a variety of industrial and consumer applications. Chief characteristics of the resins are ease of handling, toughness and chemical resistance.

1. Reinforced polyesters

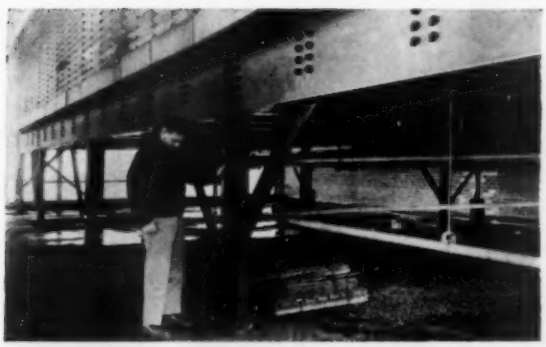
Naugatuck Chemical Co., Div. of United States Rubber Co., 1230 Avenue of the Americas, New York 20 says it is marketing a new polyester resin that promises to speed construction and cut fabricating costs of reinforced plastics boats. The resin, called Vibrin 158A, is 10% lighter by volume than standard polyester resins now used in boat building. The resin is also specifically designed for application



THE GREAT ATTENUATOR*

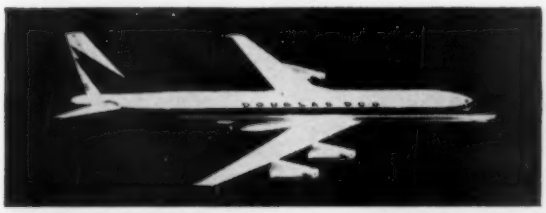
*Attenuation — Diminution of force, intensity, etc.

No other material equals LEAD'S combination of effective attenuation, low cost and compactness



IN DAMPING VIBRATION

Lead anti-vibration pads have proved an effective barrier to vibration created by railroad trains, printing presses, commerical laundry equipment and similar machinery. In the installation shown here, the roof-top cooling tower for an air conditioning system is mounted on lead pads which isolate the vibration from the building.



IN QUIETING NOISE

Because it is a dense, limp material, lead is an excellent sound attenuator and isolator. In powder form it is impregnated into the vinyl covering of a new acoustical fabric used to cut down engine roar in both conventional and jet airliners. This leaded fabric is also being used for sound attenuation in other applications such as electric typewriters.

IN RADIATION SHIELDING

X-RAY — Lead has long been the standard material for protection against harmful exposure to X-rays. It is used in the floors, walls, ceilings, doors and windows of X-ray rooms, in the protective clothing for technicians and in the beam-shaping apparatus of the machine itself.

GAMMA RAYS — Attenuation of gamma radiation is directly proportional to the density of the shield. Since lead is the densest of all commonly available materials, it gives the best protection per unit of thickness at lowest cost. It is widely used in nuclear reactors, radioactive waste containers and nuclear laboratories. Photo shows a lead-shielded fork lift truck with leaded glass viewing ports, used for transporting radioactive materials.

ST. JOE

PB-165

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What's new IN MATERIALS

by the spray gun method.

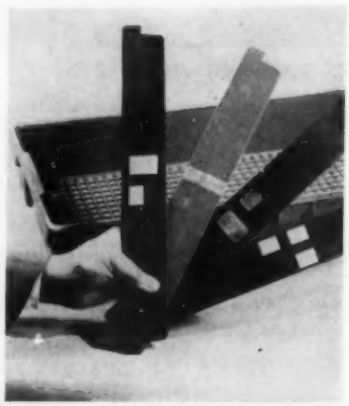
Naugatuck says the new resin wets glass fibers rapidly, and has low shrinkage, low water absorption and high impact strength. KEY NO. 624

Commercial Resins Corp., 594 James Ave., St. Paul 2, Minn. has announced development of a new isophthalic laminating resin designed for use in reinforced plastics boats. Tests show that 20 to 30% less resin is required to make the same size boat when the new resin is used in place of conventional polyesters. The resin, called CoRezyn 309, is said to wet glass fibers rapidly.

KEY NO. 625

Interchemical Corp., Finishes Div., 224 McWhorter St., Newark 5, N. J. has introduced four new isophthalic type polyester resins for use in reinforced plastics products.

1677 is a fast-curing resin designed for matched metal mold, fiberglass mat or preform work at a mold



Metal-composite laminate—Shown here are strips made out of a new metal-composite laminate introduced recently by Taylor Fibre Co., Norristown, Pa. The strips are used in automated post office equipment.

Taylor says the new laminate is designed especially for applications requiring intermittent electrical contact. It is made by embedding metal in a strong, durable insulating material (composition not disclosed). Although initial work has been done with copper, cold rolled steel, and stainless steel, the producer says virtually any metal can be used in making the laminate. KEY NO. 626

HOW NEW CHASE® ALLOY REDUCED PRODUCTION COSTS AND MADE A BETTER FAUCET HANDLE!

The handle which operates the Moen faucet—the original one-handle mixing faucet—was made formerly using two pieces of stainless steel which had to be brazed together. This took time, caused production difficulties.

Then the Western Automatic Machine Screw Company, Division of Standard Screw Company, maker of the faucet, turned to Silnic® Bronze—the new alloy by Chase. Parts are now cold-formed progressively from .368 Silnic wire—with these advantages to the manufacturer:

- Silnic parts have equivalent wear resistance to stainless steel in the bearing parts
- Cold-forming of the parts from Silnic wire eliminates and reduces production steps
- Silnic parts take an excellent chrome-plated finish
- Faucets have better resistance to detergent-caused corrosion.

And parts cost less to make because the production savings far outweigh the slightly higher cost of Silnic compared to stainless steel.

If better production and lower cost, better on-the-job performance and a longer-lasting part are what you're looking for, talk about Silnic with your nearest Chase representative. Or write Chase at Waterbury 20, Connecticut.

Chase

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What's new IN MATERIALS

temperature of 250 F. Outstanding features of the resin are toughness and resiliency. It has excellent mold release properties and cures without crazing or cracking in resin-rich areas.

1707 is a companion resin to 1677, except that it develops somewhat higher rigidity.

1709 is designed specifically for hand lay-up work. It has excellent wetting properties and produces laminates having slightly higher flex strength than conventional orthophthalic resins.

1612 has been formulated especially for use in blending with 1677 and 1707 resins. **KEY NO. 627**

2. Polyester coatings

Goodyear Tire & Rubber Co.'s Chemical Div., Akron, Ohio has developed a new family of polyester resins. Called Vitel, the resins are expected to be used as clear, tinted or colored coatings for metals and such automotive hardware as bumpers and wheel covers. They are also expected to be used in hot melt adhesives and coatings, and in wood stains, toners, primers and finishes.

Vitel polyester resins are said to have exceptional resistance to abrasion, ultraviolet rays, chemicals and weather. Other advantages include excellent adhesion, high clarity, good electrical properties and the ability to bind pigments.

Goodyear entered the polyester market two years ago with the introduction of a heat-seal polyester film (M/DE, May '58, p 141).

KEY NO. 628

3. Polyester sheeting

Eastman Chemical Products, Inc., 260 Madison Ave., New York 16 has developed a polyester resin that can be extruded into tough, clear sheeting. The extruded sheeting is said to have a high heat distortion point, low moisture absorption, good chemical resistance, and excellent electrical

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What's new IN MATERIALS

properties.

The new resin is currently being made into sheeting by Acme Backing Corp., Stamford, Conn. The sheeting is recommended for use as electrical insulation and for packaging applications. **KEY NO. 629**

Five-Layer Coating Is Strong, Heat Resistant

A need for an electrically resistant, mechanically strong, heat resistant coating for metal parts prompted researchers at General Electric's Knolls Atomic Power Laboratory, Schenectady, N. Y. to develop a new coating that consists of five alternate layers of titanium dioxide and aluminum oxide, with sodium silicate as a binder for the aluminum oxide.

The researchers, R. E. Mistler, G. L. Ploetz and A. T. Mucigrosso, say the initial titanium dioxide layer provides the required electrical resistance, and the aluminum oxide-sodium silicate slurry provides mechanical strength and heat resistance. Information on properties and uses of the coating has not been revealed.

How coating is applied

An initial coating of titanium dioxide is deposited on cleaned and vapor blasted metal by reacting titanium chloride vapors with mois-

***Two metal specimens** as they appear after being coated with five alternate layers of titanium dioxide and aluminum oxide.*

Presstite *Pressure-Sensitive* felt tape

Simplifies application most anywhere felt is used to cushion or to seal against moisture or air. Just unroll the tape and press into place with thumb or fingers. That's all. The pressure-sensitive adhesive clings tight. No need for brushes, glues, hammers or tools.

Prompt shipment DIRECT FROM MANUFACTURER . . . so you know there's a supply ready for shipment in the type and width you want.

Three Types:

- No. 500 FELT—Untreated top quality felt with pressure-sensitive adhesive.
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For data, prices, and samples write Dept. I-23. Also, see our catalog of sealants in Sweets' Design File.

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What's new IN MATERIALS

ture in the air. An aluminum oxide coating is then applied over the titanium dioxide coating by air brush spraying. After drying, the surface of the aluminum oxide coating is sealed with another application of titanium dioxide. Then another coating of aluminum oxide is applied and dried. A final coating of titanium dioxide is deposited over the aluminum oxide coating.

Nickel-Copper Alloy for Electrical Parts

A leaded nickel-copper alloy is said to have a combination of properties that suggest such end uses as electrical contacts, connectors, control elements for power tubes, electronic equipment, and structural elements now using copper.

The alloy, called Leaded Nickel Copper-831, was developed by American Brass Co., Waterbury, Conn. It is supplied in round rod in sizes from 3/32 to 1¼ in. in dia.

Chief advantages of the alloy are good corrosion resistance, high tensile and yield strengths, high electrical conductivity, and good machinability. Its machinability rating is 80 compared to free-cutting brass at 100.

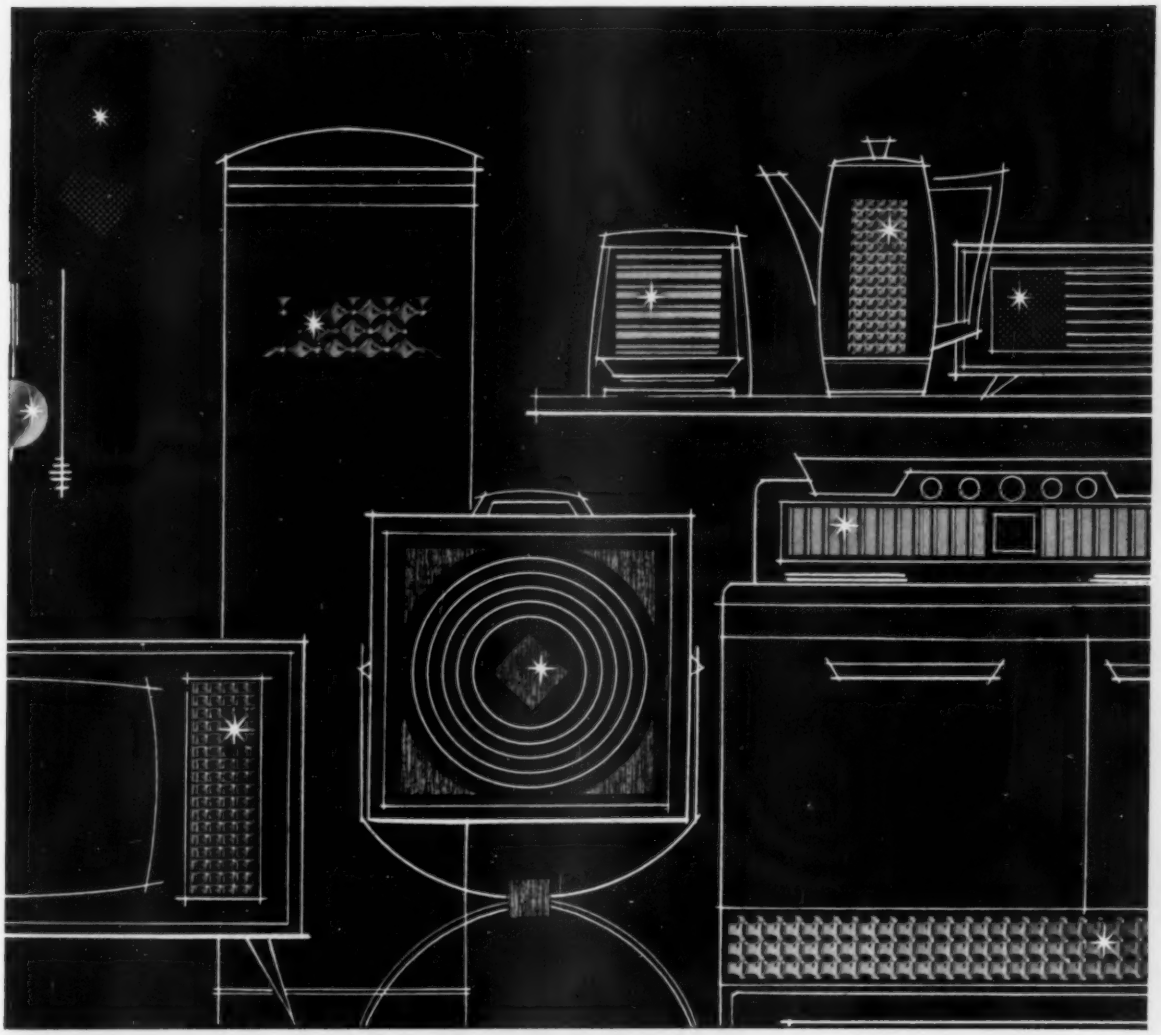
The alloy has a nominal composition of 97.8% copper, 1% lead, 1% nickel and 0.2% phosphorus. The nickel and phosphorus combine to form nickel phosphide. When heated, the nickel phosphide goes into solid solution in the copper and is retained in solution by quenching. Subsequent heating precipitates the nickel phosphide from solid solution in a highly dispersed manner, giving strength to the alloy. Subsequent cold working such as drawing or rolling increases strength still further.

Since lead and nickel phosphide are not in solution when the alloy is

PROPERTIES OF ALLOY 831*

Min Ten Str, psi	85,000
Min Yld Str (0.2% offset), psi	75,000
Min Elong (in 2 in.), %	5
Min Elec Cond, % IACS	55
Machinability (free-cutting brass = 100)	80

*Tests performed on heat treated and drawn rod measuring 3/32 to ⅜ in. in dia.



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It's those little finishing touches . . . a gleaming nameplate . . . a shimmering piece of trim . . . that make such a big difference in the appearance and appeal of your products. Any type of decorative trim you want is yours at amazingly low cost with Fasson self-adhesive materials.

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*Mylar is a DuPont Polyester Film.

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For more information, circle No. 407

in the precipitation hardened condition, it has a higher electrical conductivity than other standard copper alloys. **KEY NO. 630**

Additives Flameproof Plastics, Wood, Fibers

Clear and light colored plastics with good flame retardance are promised with the development of six new additives by the Organic Chemicals Div. of Monsanto Chemical Co., Lindbergh & Olive Rds., St. Louis 24, Mo. The additives are also expected to provide flame retardance to synthetic fibers, rayon, paper and wood products.

The additives, trademarked Phosgard, are a series of heretofore unknown organophosphorus compounds. They are described as clear, essentially odorless liquids.

Tests show the compounds are effective flame retardants for such resin systems as polystyrene, polyesters, phenolics, acrylics, epoxies, polyurethanes and polyolefins.

Two series available

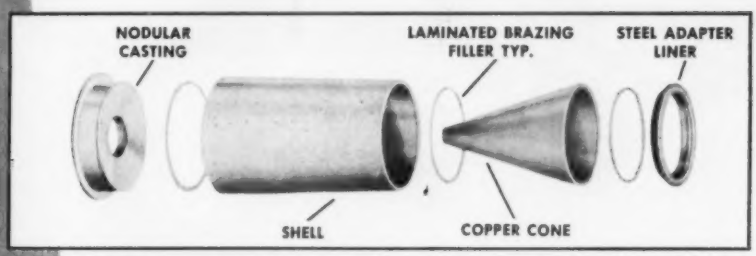
The six new flame retardants have been designated C-22, C-22-R, C-32, C-32-R, B-52-R and B-20. Both the C series (denoting chlorine) and the B series (denoting bromine) are available in evaluation quantities. Phosgard C-22-R is obtainable in drum lots.

The company expects a future volume price range of 30 to 35¢ per lb for the chlorine-containing C series of products and 50 to 60¢ per lb for the bromine-containing B series. **KEY NO. 631**

Phenolic Compounds Mold, Cure Fast

Two new phenolic molding compounds are commercially available from Union Carbide Plastics Co., 30 E. 42nd St., New York 17. The maximum preform temperature of both materials is about 295 F, or 20 °F higher than that of other fast curing phenolic compounds. This

For more information, turn to Reader Service card, circle No. 391



The four components of the nose assembly—nodular iron casting; low-carbon welded steel canister which measures 34" long, 15½" diameter at one end and 17¾" at the other; spun copper cone and low-carbon steel ring. The thinner rings are Easy-Flo 45 wire braided for precise alloy position and control.

Martin Develops New Induction Heating Methods to Braze Lacrosse Missile Assembly With EASY-FLO 45

One of the largest assemblies yet brazed by induction-heating techniques is a section of the Lacrosse missile being manufactured at The Martin Company's Baltimore Division. During development, one problem was posed by the variety of metals used. First it was necessary to braze a low-carbon welded steel canister and nodular iron casting. Then, to complete the assembly, a spun copper cone and low-carbon steel ring were joined to the canister. An induction coil was designed by Martin to accomplish this critical operation. Temperatures had to be restricted between 1300 and 1350°F to prevent a transformation change to the crystalline structure of the nodular iron. Martin's Materials Engineering Laboratory made careful examinations of this assembly and found that Handy & Harman Easy-Flo 45 Silver Brazing Alloy and B-1 Flux make possible the strong, uniform joints necessary to meet the stringent requirements the Company has set. Its low-working temperature, high strength, fast penetration and flow characteristics are only a few of the features which make this brazing alloy ideal.

More and more aircraft and missile components are being made with the aid of Handy & Harman silver brazing alloys and flux. The products described here are just two of the many available to help solve your problems...make your job easier and quicker. For a more complete picture of silver brazing and the advantages it offers you, write for your free copy of Bulletin 20.

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higher preform temperature is said to permit faster cures and shorter molding cycles, resulting in increased output rates.

The two products are two-step, general purpose molding compounds that differ mainly in granulation and fines content.

BMM-7001 is a dust and fines-free material that is especially suitable for automatic compression molding.

BMM-7002 is a similar material that is recomended for plunger molding. **KEY NO. 632**

PROPERTIES OF BMM-7001 AND BMM-7002 PHENOLIC MOLDING COMPOUNDS

PYSICAL PROPERTIES	
Specific Gravity	1.34-1.37
Water Absorption, %	0.5
Mold Shrinkage, in./in.	0.003-0.005
MECHANICAL PROPERTIES	
Tensile Strength, psi	7500
Flexural Strength, psi	10,000
Mod of Elast in Flex. 10^6 psi	34,000
Impact Strength (Izod, notched), ft-lb/in.	0.29
ELECTRICAL PROPERTIES	
Dielectric Strength, v/mil	350
Dielectric Constant	
60 Cps	5.7
10^3 Cps	5.3
10^6 Cps	4.7
Dissipation Factor	
60 Cps	0.07
10^3 Cps	0.04
10^6 Cps	0.03
Volume Resistivity, ohm-cm	10^{12}

Heat Resistant Gasket Materials

Two new gasketing and packing materials for high temperature applications have been introduced recently.

One material is made of fluorocarbon resins and inorganic fibers; the other is made of aluminum alloy wire cloth impregnated with silicone rubber.

1. Reinforced fluorocarbon

The reinforced fluorocarbon gasketing and packing material can be used at temperatures from —425 to 500 F. Armstrong Cork Co.'s Industrial Div., Lancaster, Pa., developer of the material, says its new family of gasketing materials is inert to most chemicals over a wide temperature range and has a low coefficient of friction, making it useful as seals and packings in contact with moving parts.

The materials, called Fluorocarbon Accopacs, are supplied in various proportions of resin and binder and in different densities. They are made by a modified beater saturation process (details not revealed) in which each fiber is given a thorough coating of resin and the fibers are evenly distributed to form a uniform material. (For more information on the beater saturation process, see M/DE, Oct '59, p 100.)

Armstrong says the materials have good dielectric properties, excellent thermal dimensional stability, excellent resistance to deformation under load, and good resistance to cold flow.

The family of gasketing materials will probably find use as gaskets for glass pipe, centrifugal pumps, motors, aircraft fuel systems, electrical transformers, circuit breakers, air compressors, tanks and oxygen masks. **KEY NO. 633**

2. Aluminum-silicone

The aluminum wire cloth-silicone rubber gasketing material can be used at temperatures from —65 to 500 F. It is called Cohrlastic conductive gasketing and is available from Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

The company says the conductive gasketing conforms easily to irregular surfaces and is impervious to most fluids. It is supplied in two types: No. 8516 has a 30-mesh aluminum wire cloth base and No. 8520 a 24-mesh wire cloth base. Both are impregnated with a 50-durometer silicone rubber.

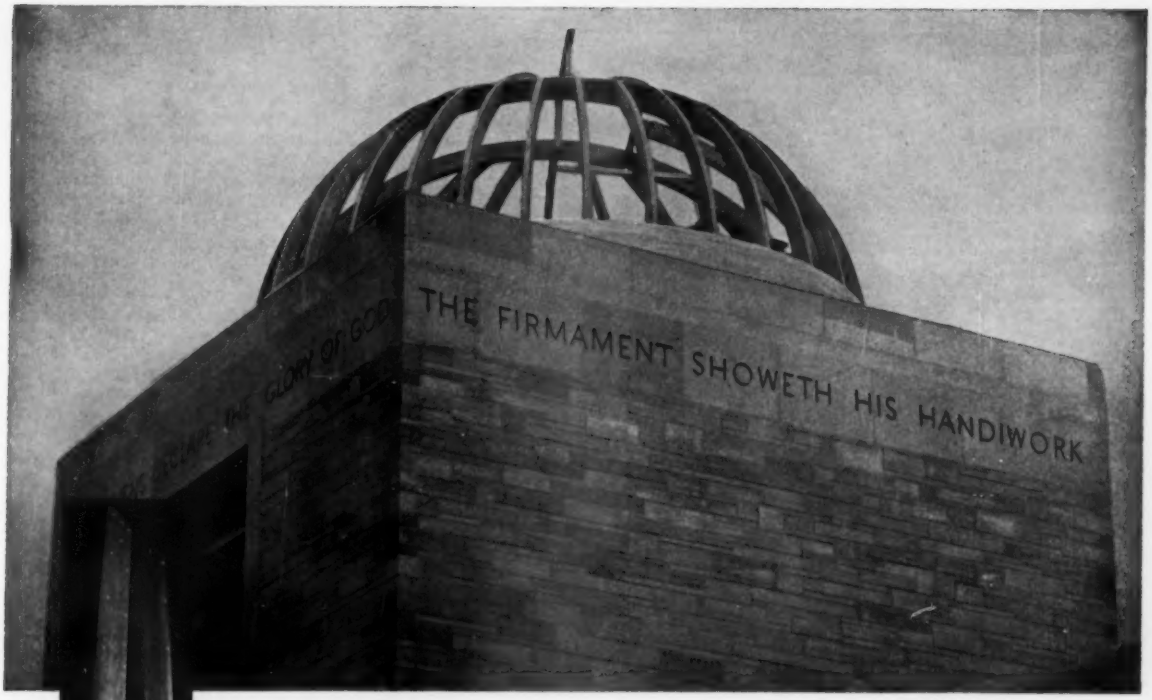
The aluminum wire cloth meets AMS 4182A and the silicone rubber meets AMS 3302B.

The conductive gasketing material is said to be ideally suited for waveguide gasketing, for shielding between magnets and their bases, in ignition harnesses, in quick disconnect plugs, and in telecomputing equipment. **KEY NO. 634**

Magnesium Sheet Suitable for Tooling

A new tooling material, magnesium phototemplate and layout sheet, has been developed by Dow Metal Products Co., Div. of Dow Chemical Co., Midland, Mich.

Dow says the material has excel-



from deflector bars... to observatory domes...

GAMBLE solves problems with WOOD!

PROBLEM: Solid wood conveyor deflector bars were splitting and breaking from repeated impact of conveyed objects, causing downtime expense.

SOLUTION: Gamble wood engineers developed a *laminated hickory* deflector bar—thinner and more resilient, yet with greater and more uniform strength (due to lamination and the characteristics of hickory).

PROBLEM: Butler University, Indianapolis, needed a hemispherical dome for its J. I. Holcomb Observatory. The material for the 360-degree-rotating dome had to offer maximum dimensional stability *plus* beauty in keeping with the overall design.

SOLUTION: Gamble Brothers provided curved, laminated, wooden ribs for the 24-foot Observatory dome, and another giant "umbrella frame" for the Planetarium dome.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

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4627 Allmond Avenue, Louisville, Kentucky

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lent flatness, and is recommended for both the diazo and blueprint methods of reproduction. Development work is continuing to make the product acceptable for photographic reproduction methods.

The sheet is supplied chemically treated with a chrome pickled surface ready for priming or coated with a primer.

The company says the magnesium sheet offers the lightest weight of any sheet metal tooling material and thus can reduce worker fatigue and freight charges. For example, a 0.051-gage sheet measuring 48 by 144 in. weighs 22.6 lb in magnesium, 34.9 lb in aluminum and 99.8 lb in steel.

Magnesium phototemplate and layout sheet is furnished in widths up to 60 in., lengths up to 168 in. and thicknesses up to 0.090 in.

KEY NO. 635

Other News . . .

Metals

▸ Specialty Wire Div. of National-Standard Co., Niles, Mich. is marketing high temperature spring wire made of René 41, a nickel-base alloy introduced in 1958 (M/DE, Nov '58, p 143). Springs made of the wire can be used at temperatures up to 1800 F, according to the producer.

KEY NO. 636

Plastics

▸ Self-adhering silicone rubber-treated glass cloth and tape are available from Micarta Div., Westinghouse Electric Corp., Trafford, Pa. Both cloth and tape are suitable for Class H (360 F) applications.

KEY NO. 637

▸ Four new, improved polystyrene compounds have been introduced by Koppers Co., Inc., Koppers Bldg., Pittsburgh 19. The four compounds, called Dylene, are: 1) No. 9, an improved heat resistant grade, 2) No. 20, a modified, medium impact grade, 3) No. 28, a modified, medium impact, heat resistant grade, and 4) No. 400, a new, high strength grade with good heat distortion properties.

KEY NO. 638

▸ Extruded, thin-walled plastics tubing for aerosol cans has been introduced by Anchor Plastics Co., Inc., 36-36 36th St., Long Island City 6, N. Y. The tubing is supplied clear, translucent or opaque in wall thicknesses down to 0.010 in., and in diameters from 1/16 to 3 in. i.d.

KEY NO. 639

Other nonmetallics

▸ Semi-Elements, Inc., Saxonburg Blvd., Saxonburg, Pa. has added ultra pure gallium and ultra pure arsenic to its line of chemical products. The company says production lot quantities of the two materials are available in purities of 99.9999%.

KEY NO. 640

▸ Micro-fine precipitated silicas for use as reinforcing fillers and thermal insulation have been introduced by Philadelphia Quartz Co., 1156 Public Ledger Bldg., Philadelphia 6. Two grades are available: Quso F 20 (slightly acid) and Quso G 30 (alkaline).

KEY NO. 641

▸ A new refractory material has been introduced by J. H. France Refractories Co., 8260 France Rd., Snow Shoe, Pa. The material (composition not revealed) is expected to be used as a lining in hot metal mixers, lime kilns and malleable iron furnaces. It has high load-bearing ability, good abrasion resistance and low porosity, according to the producer.

KEY NO. 646

Finishes

▸ A strippable plastics coating called No. 637 has been developed by Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark 12, N. J. The product is a crystal-clear cellulose acetate butyrate coating that leaves no film on metal parts when stripped away. It is supplied as a solid and melted to a liquid just before application.

KEY NO. 642

▸ A new coating (composition not disclosed) is said to penetrate cracks and pores in ferrous and nonferrous metal parts, forming a protective film 1 to 8 μ thick. It is designed for use on stored metal products, and can be removed with steam or solvents. The coating, called CRC Soft-Seal, is available from Corrosion Reaction Consultants, 116 Chestnut St., Philadelphia 6.

KEY NO. 643

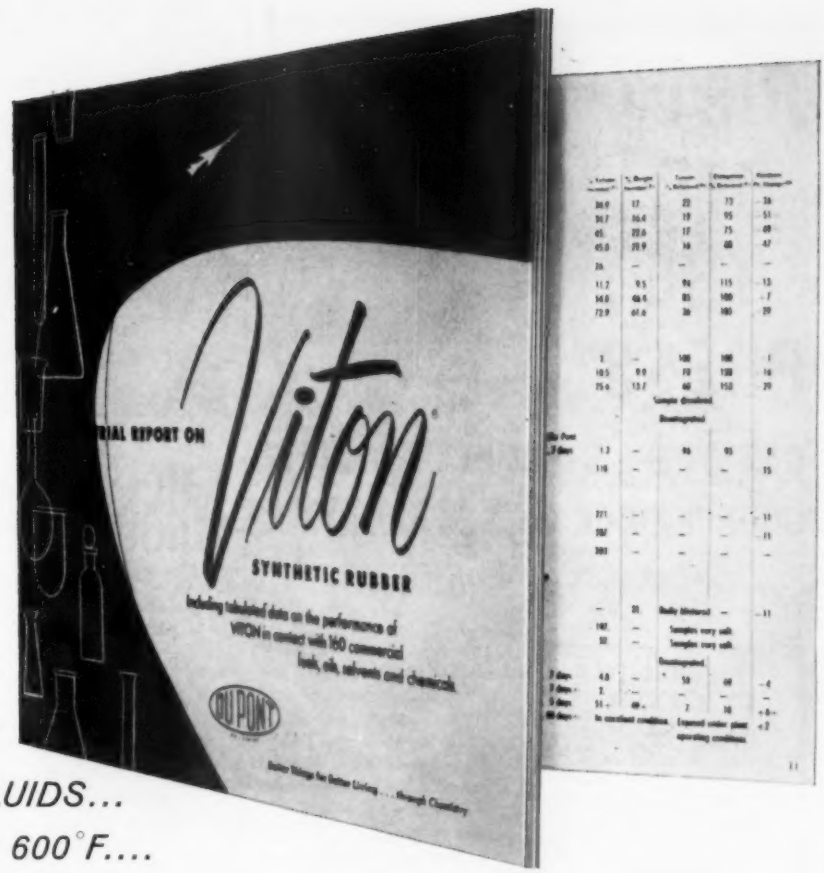
Joining and fastening

▸ Screws and nuts made of phenolic-impregnated fiberglass are said to be especially useful in applications where heat and wear resistance are principal requirements The screws and nuts, made by Pam-Pro Plastics Co., Menlo Park, Calif., are said to hold up well after repeated use.

KEY NO. 644

▸ A two-step bonding process has been developed by Plastic Associates, 2900 S. Coast Blvd., Laguna Beach, Calif. for chemically bonding nylon to metal. The method uses a two-component epoxy paste for joining nylon to metal, and a solvent solution for softening the surface of nylon so that it blends with the epoxy paste.

KEY NO. 645



HOW TO COMBAT
160 DIFFERENT FLUIDS...
AND HEAT UP TO 600°F....

WITH VITON® SYNTHETIC RUBBER

In a centrifugal heat exchanger, *heat-resistant O-rings made of* VITON *outlast other elastomer seals 25 to 1 . . . are unharmed by operation at temperatures as high as 525° F.!*

In a refinery valve, *seat and O-rings of* VITON *still give positive shutoff after more than a year's service with benzene!*

In a tank farm loading system, VITON *packings have handled a wide range of solvents, both aromatic and aliphatic, for over two years without deforming or losing their resilience!*

THESE are just a few of the many industrial applications where VITON synthetic rubber is cutting operating costs, doing jobs no other rubber could do. "Industrial Report on VITON" brings you more examples, plus latest engineering facts and figures on Du Pont's improved heat and fluid resistant elastomer. Here's a brief summary of its contents:

COMPLETE HEAT AND FLUID RESISTANCE DATA—Seals, gaskets, hose and other products made of VITON perform at temperatures from −40° F. to +600° F. "Industrial Report on VITON" gives more details, and outlines VITON'S resistance to 160 commercial fluids.

PHYSICAL AND RESISTANCE PROPERTIES—Information is provided on hardness, tensile strength, elongation, compression set, electrical and low temperature properties, as well as resistance to ozone, weather and sun.

This reference booklet should be in *your* permanent materials file. Fill in and mail the coupon below for your copy. For information on specific parts made of VITON, and how they can cut your operating costs, see your rubber goods supplier. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MDE-11, Wilmington 98, Delaware.

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the LEAD newsletter

Vol. 2 No. 4

Unique Power Requirements Provided By Lead

Five Kilowatt Thermoelectric Generator

Ideal thermoelectric materials are hard to find. They must be semiconductors, substances with electrical properties midway between insulators and conductors, which are used in transistors and other solid state devices. However, used in a thermo-electric device, good electrical conductors generate very little voltage, good electrical insulators very little current. This restricts the search to a narrow range of materials that conduct electricity much less than metals do, but better than ordinary semiconductors. Westinghouse engineers, says Fortune magazine, have come up with five-kilowatt generator incorporating a variety of thermoelectric materials, each of which works best at a different temperature. At the hot (650° C.) end of one leg of the element is a wafer of germanium telluride, zinc antimonide, and finally, at the cold end (100° C.), an alloy of bismuth and antimony tellurides. The other leg consists of wafers of lead telluride and an alloy of bismuth and selenium tellurides. Potentially this carefully selected sequence of materials has a thermal efficiency of better than 15 per cent.

Two-Volt System Powers Cigarette Lighter-Flashlight Combination

A New York company markets a cigarette lighter with a two-volt lead-acid ceil ignition system. When a "light" is desired, a mere touch slides out a coiled resistance wire that glows incandescently and lights the wick. Several amperes of current flow during the few seconds the resistance wire is aglow. Even chain smokers can expect three to six months of service before replacement of the tiny lead-acid cell is necessary. The cell, weighing less than an ounce, is plastic covered and completely sealed, measuring 1-1/2 x 1-1/6 x 3/8 inches. In addition to being a cigarette lighter, the same lead-acid battery powers a totally functional flashlight which is built into the unit. The battery's size and characteristics indicate interesting electronic applications where compactness and intermittent high drain capabilities are requirements.

Battery Powered Trucks and Cars

Whether power requirements are minor, such as required in the lighter or major, such as needed to carry heavy loads economically over long distances, there is a lead-acid storage battery to meet every need. Because operating costs are attractively low, lead battery powered electric vehicles are a practical reality despite present slightly higher initial costs. Economy-minded local fleet pick-up and delivery truck operators see great possibilities for electric street trucks that are being marketed by the Cleveland Vehicle Co., to handle a 50-mile route with 200 pay stops. The reason: cost, a mere one-and-a-half cents a mile on the average stop-start 20 mile route. These highly efficient lead-acid storage batteries, with a low weight to power ratio can be fully recharged overnight by "plugging" into any 110 or 220-volt outlet. Passenger cars with the same economy features as exhibited by the trucks, produced by the Henney Motor Company of Canastota, New York, use an imported unitized Renault Dauphine body which is powered by 640 pounds of heavy-duty lead-acid batteries generating 72 volts of motive power, and 12 volts for lighting and control. Capable of top speeds up to 40 mph this "hot" car travels more than 50 miles before needing a recharge. It operates extremely quietly, and enables the motor to live practically forever.

Lead Zirconate-Titanate Shakes Out The Dirt

Lead zirconate-titanate, a new high efficiency, high Curie temperature piezoelectric ceramic, is the transducer material used in an ultrasonic cleaning system introduced this year by Branson Ultrasonics of Stamford, Connecticut. The system has cleaning power equivalent to the old barium titanate systems but at only two-thirds the initial cost. Although piezoelectric lead zirconate-titanate is somewhat costlier than barium titanate, its higher electromechanical efficiency generously compensates by requiring less expensive driving gears, while its higher Curie temperatures provides full-wave operation without danger of depolarizing. Total efficiency of the new lead-zirconate-titanate system is 90 per cent compared to 70 per cent for barium titanate systems. Furthermore a new transducer design concept has cut replacement costs of the transducers to negligible levels. The sandwich designed transducer consists of a thin section of ceramic clamped between two pieces of metal and operates at 25 KC. It offers advantages of: higher operating temperature (200° F.); and flat tuning characteristics which reduce the need for close frequency control of the generator. In brief: lower initial cost and lower maintenance costs resulting from the use of lead zirconate-titanate transducers make this new ultrasonic cleaning system competitive in uses formerly closed to ultrasonic cleaning.

For information or technical assistance on new lead developments and applications – and how they can relate to your products – write to: Lead Industries Association, 292 Madison Avenue, New York 17, N. Y. 2631

RITCO FORGINGS

...their economy alone merits your design consideration!

Demonstrated savings in costly machining and assembly time alone make Ritco Forgings the logical choice for many product designers and engineers. Several other features make their application even more advantageous. Forged-in toughness is one. Their dense, fibrous structure and controlled grain flow concentrate extra strength and impact resistance at points of greatest shock and stress. Consider, too, that Ritco "Bright Finish" Forgings are made to close-tolerance specifications with smooth, flaw-free surfaces to eliminate any additional finishing operations. All things considered, it will pay you to write Ritco Forgings into your specifications. Send us your blueprints for estimates at no obligation.

Ritco also offers complete machining facilities and makes Special Fasteners and Upsets of ferrous and non-ferrous metals. What are your requirements?

RHODE ISLAND TOOL COMPANY
Member Drop Forging Association
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This new Super Satellite rotary diazo printer is acclaimed by draftsmen as the fastest white-printer in the low price field. Made by Grico, Inc., of Cuyahoga Falls, Ohio, its feedboard (A) and paper guide (B) are aluminum, extruded, polished and anodized by General Extrusions, Inc.

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WE MOLD ALL THERMOPLASTICS . . . from 2 to 175 oz.

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BETTER MORE UNIFORM FINISHES AT LOWER COST

CORVEL®
fusion-bond finishes
applied by the **WHIRLCLAD†**
Coating System*

A search for **better quality** coatings uncovers new **fabricating economies.**

Colorful CORVEL vinyl finishes can do **this** for wire racks and other metal parts in dishwashers:

- *Elimination of drips, sags, pack marks and bridging*
- *Thorough coverage of edges, corners and projections*
- *Uniformity of finish on wire products and metal parts*
- *Excellent under-film corrosion resistance*
- *Odor-free—resist fading*

CORVEL is applied directly with considerable savings in material costs. The simple WHIRLCLAD process is also less expensive. Rejects are minimized.

Appliance and other manufacturers can get these benefits from CORVEL Custom Coating Service or CORVEL powders in vinyls, chlorinated polyethers, cellulosics, epoxies, nylon and polyethylene. In addition to supplying coating materials, the WHIRLCLAD Division can assist you to engineer the WHIRLCLAD System in your own plant . . . according to your specific requirements. Facilities for sample or prototype development are available.

Custom coated parts are supplied by the Polymer Corporation and other authorized sources.

For further information on CORVEL finishes, write to The Polymer Corp., WHIRLCLAD Division, Reading, Pa.

*The WHIRLCLAD Coating System includes basic procedures and apparatus developed and patented in Germany by Knapsack-Griesheim A.G. of Frankfurt, Germany. The WHIRLCLAD Coating System is protected by patents in the United States and foreign countries, and numerous patent applications are pending. Exclusive patent and licensing rights in the United States and Canada are owned by Polymer Processes, Inc., a subsidiary of The Polymer Corporation.

†Trademark of The Polymer Corporation

POLYPENCO *industrial plastics*

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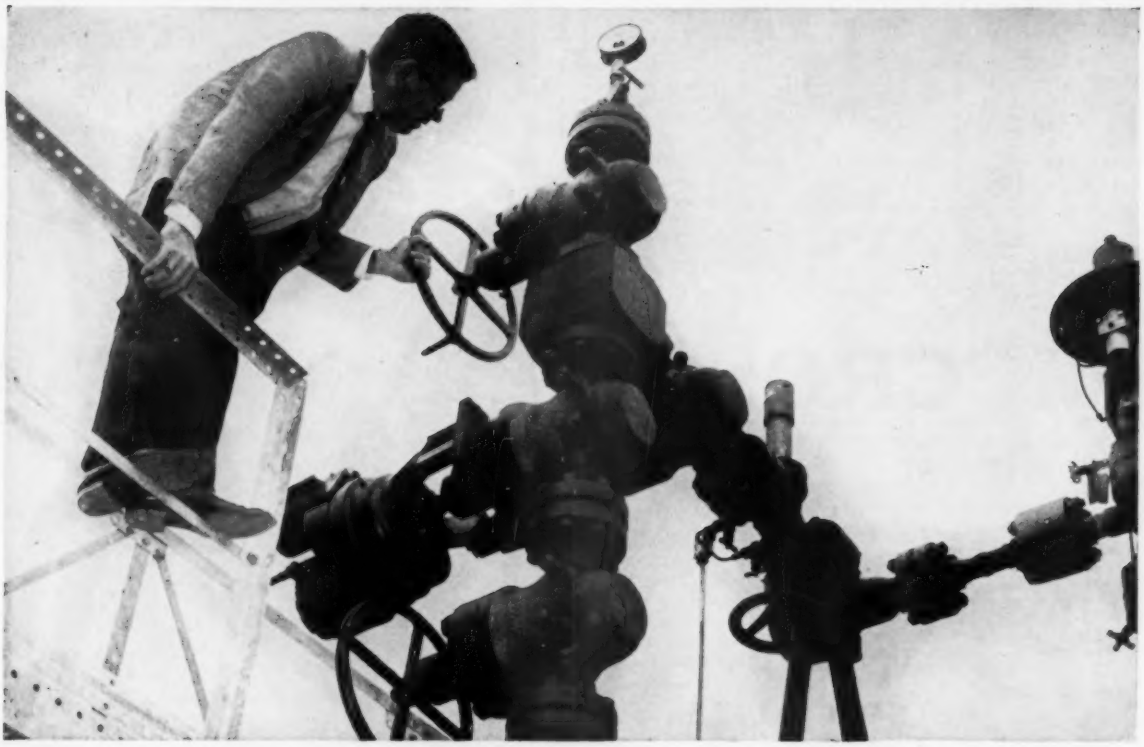

What every designer should know about

High nickel alloy springs for corrosive environments

The highly corrosive petroleum products passing through this "christmas tree" valve practically dictate the use of high nickel alloy springs. They provide specific technical and economic advantages for valves, electrical components and other applications in corrosive environments such as chemicals, sea water, mine water or power plants.

Inconel* nickel-chromium alloy offers especially high resistance to stress-corrosion cracking or embrittlement by corrosive fluids at high temperatures. Inconel "X"* alloy, which is age-hardenable, resists relaxation under corrosive conditions at temperatures as high as 1200°F...remains ductile at –320°F or lower.

Versatile corrosion-resisting properties of Inconel and Inconel "X" alloys are based, generally, on their high Nickel content for resistance to reducing media; and on their chromium content for resistance to oxidizing conditions. Thus, Inconel and Inconel "X" alloys...

- **Are unaffected by most neutral and alkaline salt solutions...are among the few materials suitable for use with hot, strong magnesium chlorides.**
- **Are exceptionally resistant to hot fatty acids...alone or mixed...including stearic, oleic, linoleic and abietic.**
- **Are practically free from corrosion by distilled or fresh water...including the most corrosive of natural waters containing free carbon dioxide, iron compounds, chlorides or dissolved air.**
- **Are bright metals and retain their brightness indefinitely in most indoor locations.**

Helpful new Technical Bulletin T-35, "High Nickel Alloy Helical Springs," gives valuable design, fabricating and specifying data on springs of Inconel alloys and other corrosion-resisting high nickel alloys. On "K" Monel* and Duranickel*, for example ...for effective service with such corrosives as mineral and organic acids, alkalies, salts...potable and industrial waters...food products, organic compounds and oxidizing atmospheres at normal and elevated temperatures. Find out more about the design advantages of high nickel alloy springs – available hot or cold wound. Write for newly-revised Technical Bulletin T-35, "High Nickel Alloy Helical Springs."

*Inco trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCO TRADE MARK **ALLOY PRODUCTS**

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Go Goshen **RUBBER**

PARTS SEALS PRODUCTS

.....**O-RINGS**

TO MEET ADVANCED REQUIREMENTS

Capitalize on Goshen's experience in serving the needs of hundreds of large and small users of o-rings in the United States and Canada. Precise control of quality thru every stage of formulation and manufacture is the key to an outstanding record of sealing success.

GRC o-rings in all standard AN, MS, SAE and JIC sizes, in many non-standard sizes and in special sizes, are available from established and proven synthetic and silicone specification compounds. Go Goshen for efficient sealing under most any given conditions.

Ask for your free copy of 16-page O-ring Brochure on size, groove dimensions, compounds and other helpful information.

Goshen Rubber Co., INC.

3111-O S. TENTH ST. GOSHEN, INDIANA

For more information, turn to Reader Service card, circle No. 386

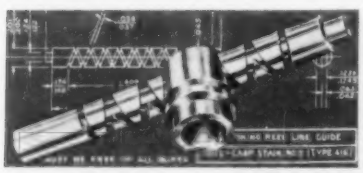
What **other** material gives you this **range** of desirable properties?

Here's a handy reference to the performance characteristics of Carpenter Stainless Steel. Tear out this information and file it. It may help you make the right decision in selecting the best material for your next assignment.

Greater hardness range

Only stainless steels can give you the combination of good corrosion resistance with sufficient range of hardness to meet any of your requirements. For example, fully annealed 18% Cr-8% Ni stainless steels such as Carpenter Stainless No. 4-A (Type 304) have a Brinell hardness of about 150, whereas heat treated Carpenter Stainless No. 440-C (Type 440C) can be as hard as 600 Brinell and both materials offer excellent resistance to a wide variety of corrodents. The range of hardnesses available with either copper-base or aluminum-base alloys is much smaller.

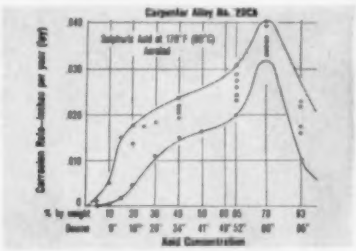
Superior machinability



The selection of Carpenter Stainless No. 5 (Type 416) for this level wind shaft for a fishing reel gave the manufacturer good machinability and eliminated expensive handwork on the shaft. It also provided excellent resistance to corrosion and unbeatable wearing qualities. A good example of a wise choice in metal selection.

Better corrosion resistance

The wide range of stainless steels available offers the designer the exact degree of corrosion resistance necessary for almost any corrosive environment. For mild corrodents, inexpensive Carpenter No. 1 (Type 410) can be used; for extremely severe corrodents such as hot sulphuric acid solutions, Carpenter No. 20Cb should be specified. For other corrodents, one of the many other stainless steels will be the most economical material for you to use.



Carpenter No. 20Cb is a special alloy first produced by Carpenter in wrought form. Its excellent resistance to hot sulphuric acid is shown in the chart above. For information on its resistance to other corrodents, send for booklet, "Super Corrosion Control".

Easier quality control

Here's an application where Carpenter Stainless No. 8 (Type 303) provided an unexpected bonus! These bushing and shaft assemblies for a push-button unit in an explosion-proof switch were formerly made from a non-ferrous metal. After switching to Carpenter Stainless No. 8 (Type 303) to gain more uniform machinability and non-corrosive properties, this customer eliminated a costly inspection operation on the finished shafts. This was due to the consistently true size of the No. 8 bars (total tolerance: .0005" as supplied by the Carpenter mill).

Carpenter Stainless is available to the designer in many forms. Billets, bars and wire in a wide range of sizes . . . strip, tubing or pipe of varying thicknesses. Whatever form best suits your needs, you'll find one unique feature of Carpenter Stainless . . . its *consistent uniformity*. There's never the slightest change in composition in any one grade of Carpenter Stainless, no matter how big the order. Day after day, year after year, each melt of Carpenter Stainless is carefully controlled with the best equipment and human effort to bring you a reliable, consistent material, unsurpassed in uniformity. When the product you design goes into production, this consistent uniformity becomes extremely important. Specify Carpenter Stainless, and take a big step toward approval of your project.

Technical data available

Complete information on properties and characteristics of all grades of Carpenter Stainless is available in data sheet form. Send for yours today.

Are you getting all these performance characteristics in the materials you specify?

- ☐ *brilliant finish*
- ☐ *maximum strength*
- ☐ *corrosion resistance*
- ☐ *uniformity*
- ☐ *hardness*
- ☐ *versatility*
- ☐ *good machinability*
- ☐ *ease of fabrication*
- ☐ *exacting tolerances*
- ☐ *long service life*
- ☐ *customer satisfaction*

Carpenter Stainless gives you *all* these . . . and more!

Carpenter steel

you can do it ***consistently*** better with Carpenter Stainless Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

For more information, turn to Reader Service card, circle No. 346

LINDE 99.9% Pure ALUMINA ABRASIVES

BULOVA WATCH PINIONS (sample shown magnified 100x) now have important surfaces polished to a high precision finish with LINDE alumina abrasives. Actual size is at right →

Permit Critical Finishing of ALL Modern Metals with ONE BASIC MATERIAL

No longer need the minuteness of a metal part, or its shape, or its type of metal interfere with the quality of its finish.

All-new LINDE abrasive powders—of 99.9% pure alumina—now permit precision finishing and polishing, as well as sharpening and honing of many metal parts—with *one basic material.*

Depending upon usage, LINDE alumina powders can be used dry, mixed with water or other vehicles to make a thin slurry or heavy paste, or compounded with waxes in convenient stick form. They are uniform in size, thus eliminating levigation in finishing operations. And they are resistant to common acids.

Only two grades of these low-cost, fast-cutting, high-purity white powders are required: LINDE A (*alpha alumina*) for quicker cutting and an unsmeared finish; LINDE B (*gamma alumina*) for somewhat slower cutting but an extremely fine finish.

For details on alumina abrasives as applied to your production problems, write Dept. MI-11, Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York. *In Canada:* Linde Company, Division of Union Carbide Canada Limited, Toronto 12.

PHYSICAL PROPERTIES

	Type A-5175	Type B-5125
Chemical Formula	Al_2O_3(Alpha)	Al_2O_3(Gamma)
Crystal System	Hexagonal	Cubic
Hardness, Mohs'	9	8
Particle Size approximate (microns)	0.3*	<0.1
Apparent Density (g/c.c.)	0.3-0.6	0.2-0.5
Melting Point	2050° C.	Transforms to Alpha form at high temperatures

*Type C-5250 also available in 1.0 microns (approximate) particle size.

SUGGESTED USES

CHEMICAL: Catalyst Carrier • **ELECTRONICS:** Semiconductor Polishing • **JEWELRY:** Gem Stone and Crystal Polishing; Silver Polishing • **LIGHTING:** Phosphor Preparation • **CERAMICS:** Pure Oxide Ceramics • **METAL FABRICATION:** Finishing of Metal Parts; Knife Sharpening; Microtome Knife Sharpening; Razor Blade Sharpening • **METALLURGY:** Metallographic Polishing • **OPTICAL:** Glass Polishing

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

UNION CARBIDE

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STATEMENT OF THE OWNERSHIP, MANAGEMENT AND CIRCULATION REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, JULY 2, 1946 AND JUNE 11, 1960 (74 Stat. 208) of MATERIALS in Design Engineering, published monthly with an additional issue in Mid-November, at New York, N. Y., for October 1, 1960.

1. The names and addresses of the publisher, editor and managing editor are: Publisher, William P. Winsor, 400 East 52nd Street, New York 22, N. Y.; Editor, H. R. Clauser, Valley Lane, Windmill Farm, Armonk, N. Y.; Managing Editor, John B. Campbell, 75-20 113th Street, Forest Hills, L. I., N. Y.

2. The owner is: Philip H. Hubbard, 2 Bon Mar Road, Pelham Manor, N. Y.; William P. Winsor, 400 East 52nd Street, New York 22, N. Y.; Profit Sharing Trust, 430 Park Avenue, New York 22, N. Y.; Fred P. Peters, 45 Forest Drive, Short Hills, N. J.; H. Burton Lowe, 18 Onderdonk Avenue, Manhasset, L. I., N. Y.; Merald Lue, 335 Newtown Turnpike, Wilton, Conn.; Kathleen Starke, 266 Bedford Park Boulevard, Bronx 58, N. Y.; John Y. Cunningham, 412 East 55th Street, New York, N. Y.; John F. LeVinese, Jr., 10 Oak Street, Floral Park, L. I., N. Y.; Gessner G. Hawley, 328 West 58th Street, New York, N. Y.; David B. Wilkin, 80 Devoe Road, Chappaqua, N. Y.

3. The known bondholders, mortgagees and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: None.

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5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: 28,902.

William P. Winsor,
Publisher.

Sworn to and subscribed before me this 28th day of September, 1960.
(SEAL)

Kathleen Starke,
Notary Public.
(My commission expires March 30, 1962.)

Coming in November . . .

1961 MATERIALS SELECTOR

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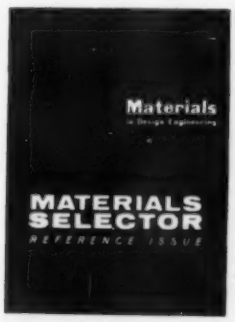

***These manufacturers advertised their products in the 1960-61 MATERIALS SELECTOR REFERENCE DATA ISSUE**

For more complete information, and application data on their lines, refer to the index of Advertisers in the Mid-November MATERIALS SELECTOR ISSUE of MATERIALS IN DESIGN ENGINEERING.

THE LAST WORD

Coming Soon: 2½ Lb of Materials Reference Data

by H. R. Clauser
Editor

Within the next couple of weeks or so our reference data issue—the *Materials Selector Issue*—will reach your desk. It will have 592 pages and weigh 2½ lb. And, if our statistics on previous years are correct, you will refer to it at least once a week.

Now, with a few slides of the slide rule, and by making a few assumptions about the size of your desk and your muscles, it turns out that during the next twelve months you will be performing a minimum of about 800 ft-lb of work in lifting the issue back and forth across your desk. Should it be necessary for you occasionally to carry it away from your desk, you can easily see that the work performed in using the issue will quickly rise to many foot-tons.

Is it worth it?

Is the *Materials Selector Issue* worth that much exertion on your part? We think so. For our part, we have spent a total of about 9000 man-hr creating, developing and preparing it for you. About two-thirds of this work went into collecting, verifying and organizing the 50,000 entries of property and processing information on 1000 materials, forms and finishes. The other third was spent gathering and preparing the 17,000 listings that make up the Directory Section of materials suppliers.

Of course, the weight of the issue and the man-hours spent in preparing it are not the real measure of the value of its content. The only true measure is how much it helps you in your job of selecting the best material for a particular product or application.

It's how it's organized that counts

We know from the many comments received on previous issues that the *Materials Selector Issue* does provide a helpful guide to solving your materials application problems. Its helpfulness, we are told can be attributed largely to the fact that the data and information are so organized that you can systematically narrow your choice of materials to meet a specific problem.

Thus, you can first go to the Comparisons of Materials section and find the materials that will meet the most important of your product or performance requirements. From there you can look up the detailed properties of your selections in the Properties of Materials section. At the same time, you can refer to the Forms, Shapes and Composites section and to the Joining and Fastening section for information on how your materials selections can be formed and fabricated.

Sometime during this selection process you can turn to the Directory Section to obtain the names and addresses of the suppliers of the most promising materials and forms. Also, a great many of the advertising pages will give you more detailed information on the materials you are considering, or will describe specialty materials that are not included in the editorial data pages.

It's not a cure-all

The issue, of course, does not provide all of the data needed to solve materials selection problems. It is not an easy substitute for hard work and good engineering judgment. In many cases you will still have to make your own independent evaluations and tests, seek additional information, and develop more precise design data. But the issue does bring together in a concise and organized fashion a great wealth of data which should give you a good start on the way to finding solutions to your materials application problems.

CELANESE MATERIALS REVIEW

- ☐ **FORTIFLEX linear polyolefins**
- ☐ **FORTICEL cellulose propionate**
- ☐ **ACETATE molding compounds**
- ☐ **ACETATE sheeting**
- ☐ **POLYESTER resins**

Design and cost advantages spur demand for Celanese reinforced polyester resins

Whether your product is a button or a boat—big or small—a change to polyester reinforced plastics could boost your profits. Celanese polyesters offer equal or better strength and stiffness than the materials which you may now be using.

FROM RADIO CAPACITORS TO AUTO BODIES

Among the most versatile and economical of plastics, polyesters are especially effective for fabricating large, rigid shapes or small intricate parts. If you are designing machine housings, exhaust ducts, truck bodies, boats, tote boxes, or decorative items such as desk sets, trophy bases, lamp shades or buttons, it will pay you to investigate the economies and improvements made possible by polyester resins. Polyester resins, reinforced with glass, are among the strongest materials available today on a strength-to-weight ratio.

CELANESE OFFERS A SWEEP OF FORMULATIONS

Thirty-five formulations are available from Celanese. Check this listing of major types for an idea of their versatility:

General purpose resins
Flexible resins
Flame-resistant resins
Preform and premix molding resins
Casting resins
Marcothix high-viscosity resins
Light stable resins
Low exotherm resin
Fast cycle hand lay-up resins
Electrical resins
Auto body repair kit resins

VARIED PRODUCTION PROCESSES

With Celanese Polyester resins, production runs as well as item size can vary from large to small. Cure is effected by catalyst, without the need for heat or pressure. Products emerge with a high-gloss—sturdy, rigid, ready for use. Fabrication techniques include hand lay-up, spray-up, preform or premix molding, casting and vacuum bag molding.

LET CELANESE HELP YOU

The Celanese Technical Service and Application Laboratory offers experienced assistance in all phases of polyester applications. If you plan to make a product where polyesters may be suitable, a consultation with Celanese on costs, methods, formulations and key design factors can be valuable to you.

Celanese® Fortiflex® Forticel® Marco® Marcothix®

MAKE LARGE, RIGID SHELLS, PANELS, MOLDINGS OF CELANESE POLYESTERS

TANK TRUCK
BY MARCO METHOD


OFFICE FURNITURE
BY PREFORM


AUTOMOTIVE PARTS
BY PREMIX MOLDING


BOAT HULL BY SPRAY-UP
OR HAND LAY-UP

SEND FOR NEW POLYESTER BROCHURE

File-sized folder gives detailed descriptions of Celanese Polyester resin formulations. Physical properties, handling procedures and processing methods are fully described.

Celanese
PLASTICS and RESINS

For more information, circle No. 349

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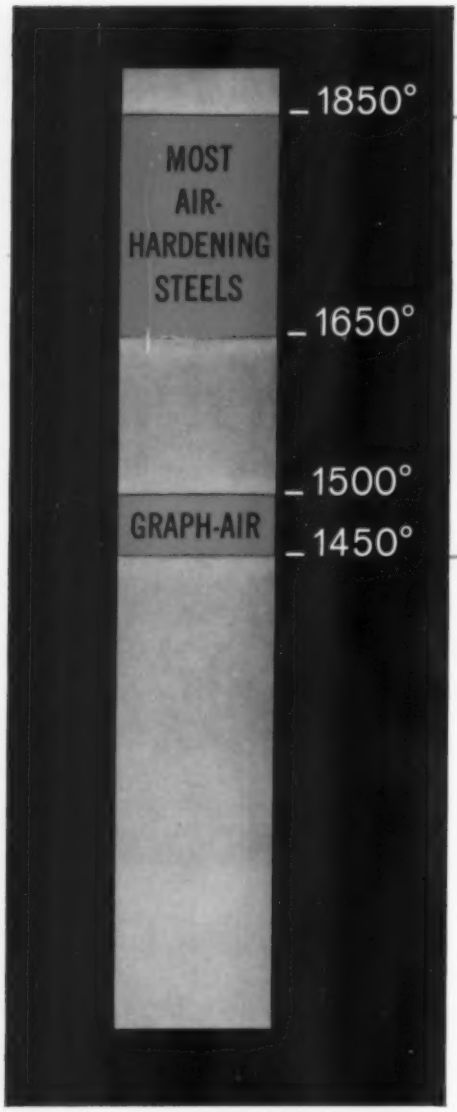

This lower hardening temperature...

makes the big savings difference in Graph-Air®

YOU save in a big way with Graph-Air® steel for your heat-treated parts. Because it air-hardens at 1450°—as much as 400° *below* most other air-hardening tool steels—you can simplify heat treating controls. You need less expensive equipment. And this air-hardening difference reduces distortion, cuts scaling and decarburization.

You save too because Graph-Air machines more easily than ordinary steels, due to the free graphite in its structure. It outwears other tool steels as much as three to one because it contains diamond hard carbides throughout. And Graph-Air holds its accuracy longer because of its built-in stability. It's one of the family of Timken graphitic tool steels, the most stable made.

You'll find the reduced distortion of Graph-Air helps make better intricate sections. And it's a preferred steel for blanking dies that must withstand punishment.

When you buy Timken steel you get . . . *1) Quality that's uniform from heat to heat, bar to bar, order to order. 2) Service from the experts in specialty steels. 3) Over 40 years experience in solving tough steel problems.*

Specify Graph-Air when you need high quality tool steel that air-hardens at lowest temperature. Available in solid and hollow bar sizes. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

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***Fine Alloy* STEEL**

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